SCIENCE

28 October 1960

Vol. 132, No. 3435

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

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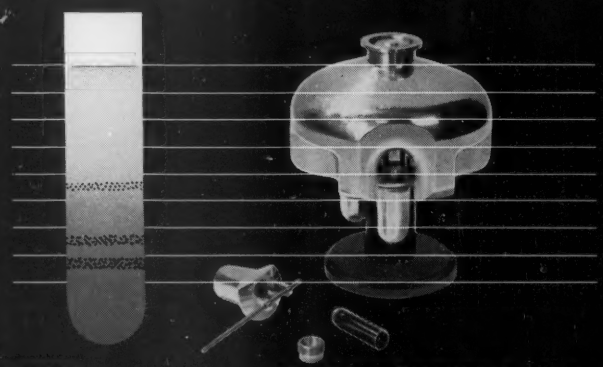

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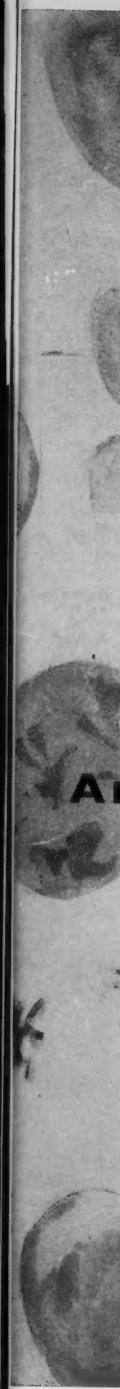

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CIENCE is published weekly by the AAAS, 1515 Massachusetts Ave., NW, Washington 5, D.C. Second-class postage paid at Washington, D.C., and additional mailing office. Annual subscriptions: $8.50; foreign postage, $1.50; Canadian postage, 75¢.

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SCIENCE

Cover

"Turkey tail" blades of chipped flint. [Photograph from *Indian Life in the Upper Great Lakes*, published by the University of Chicago Press; see page 1243]

28 October 1960, Volume 132, Number 3435 **SCIENCE**

SCIENCE, which is now combined with THE SCIENTIFIC MONTHLY, is published each Friday by the American Association for the Advancement of Science at National Publishing Company, Washington, D.C. The joint journal is published in the SCIENCE format. SCIENCE is indexed in the *Reader's Guide to Periodical Literature*.

Editorial and personnel-placement correspondence should be addressed to SCIENCE, 1515 Massachusetts Ave., NW, Washington 5, D.C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts or for the opinions expressed by contributors. For detailed suggestions on the preparation of manuscripts and illustrations, see *Science* **125**, 16 (4 Jan. 1957).

Display-advertising correspondence should be addressed to SCIENCE, Room 740, 11 West 42 St., New York 36, N.Y.

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Middle Ground

Discussion about private or public and local or national responsibility for education, for housing, and for health is often carried on as though there were no middle ground, as though the choice lay between extremes.

Any appraisal of the way things actually work will show, however, an intimate blending of private and public, local and national, responsibilities. A good example is the way methods have been evolved for dealing with poisoning by toxic substances.

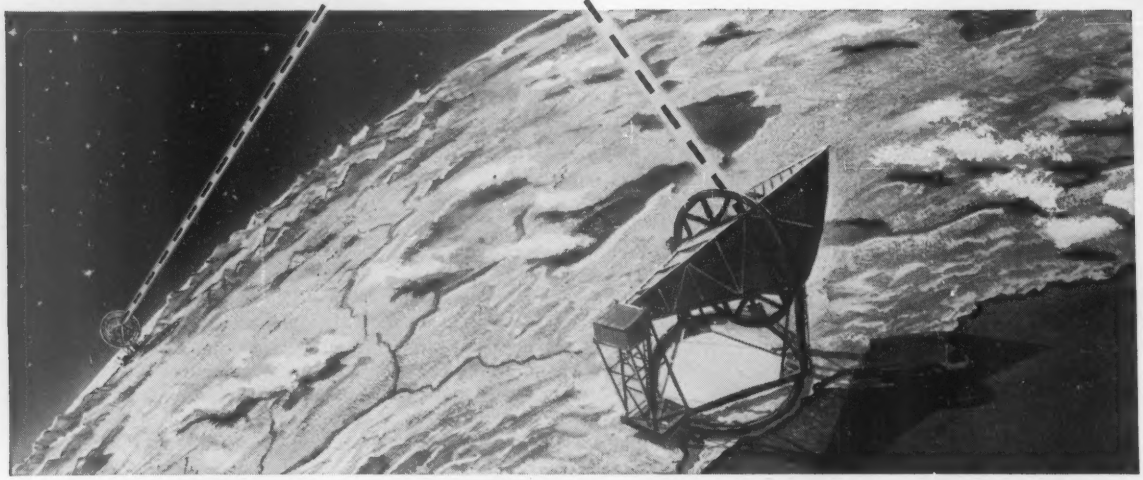
In older and simpler days the local physician could be expected to know how to deal effectively with the relatively few poisons—lye, aspirin, kerosene, and so on—that might be ingested. With the introduction of scores of new insecticides, chemotherapeutic agents, and detergents—to mention only a few of the estimated 250,000 toxic or potentially toxic products now available to consumers—the problem of appropriate treatment has increased enormously. The infant or child of today (and more than 90 percent of all poisoning victims are children) has a much greater opportunity than his predecessors did to ingest toxic liquid and solid materials not intended for his consumption. A survey by the American Academy of Pediatrics in 1951 showed that accidental poisoning accounted for more than half of all emergency cases handled by pediatricians. It was recognition of the seriousness of this problem that led to the formation of the first Poison Control Center in Chicago in 1953. The center became a focus of community effort in the prevention of poisoning and in the accumulation of information about symptoms and treatment. Other major cities followed Chicago's lead, and by 1956 centers had been established in 38 cities.

This widespread response at the local level led to recognition of the need for national coordination. Representatives of the control centers, industry, the American Medical Association, and state and federal government got together at a meeting of the American Public Health Association and recommended that the Department of Health, Education, and Welfare set up a National Clearing House for Poison Control Centers. Such a clearing house was established in 1957. It collects information about poisons and possible poisons in new products, from the control centers, from industry, and from other sources, and supplies this information free to the local centers, which now number more than 400. Many of the local centers report all cases of poisoning in their communities—some 2000 per month—to the clearing house. The accumulation and analysis of this information permits study of the epidemiology of poisoning, detection of new hazards, and extension of knowledge of human toxicology. This information is, in turn, made available to all control centers and to the medical profession in general.

This pragmatic, nondoctrinaire approach has been carried a step further. The centers have organized themselves into the American Association of Poison Control Centers, which, on 18 October, accepted a set of standards for the operation and designation of centers. Thus the federal government neither controls nor licenses the local centers; it merely furnishes all of them with information necessary to their effective operation.—G.DuS.

FIRST PHONE CALL VIA MAN-MADE SATELLITE!

"Project Echo" satellite went into a near-perfect circular orbit 1000 miles high, circling the earth once every two hours. Its orbital path covered all parts of the U. S.



BELL TELEPHONE LABORATORIES BOUNCES VOICE OFF SPHERE PLACED IN ORBIT A THOUSAND MILES ABOVE THE EARTH

Think of watching a royal wedding in Europe by live TV, or telephoning to Singapore or Calcutta—*by way of outer-space satellites!* A mere dream a few years ago, this idea is now a giant step closer to reality.

Bell Telephone Laboratories recently took the step by successfully bouncing a phone call between its Holmdel, N. J., test site and the Jet Propulsion Laboratory of the National Aeronautics and Space Administration (NASA) in Goldstone, California. The reflector was a 100-foot sphere of aluminized plastic orbiting the earth 1000 miles up.

Dramatic application of telephone science

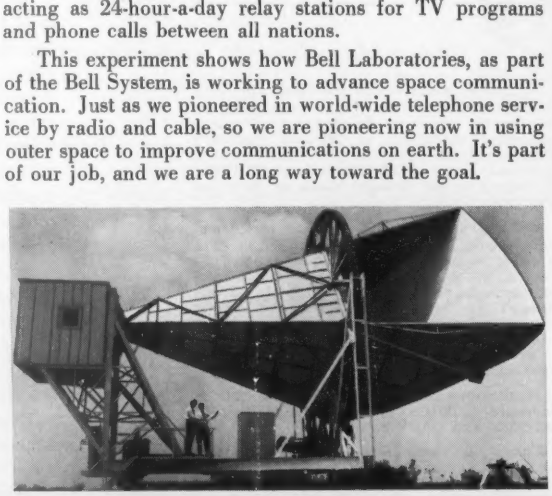
Sponsored by NASA, this dramatic experiment—known as "Project Echo"—relied heavily on telephone science for its fulfillment . . .

- The Delta rocket which carried the satellite into space was steered into a precise orbit by the Bell Laboratories Command Guidance System. This is the same system which recently guided the remarkable Tiros I weather satellite into its near-perfect circular orbit.

- To pick up the signals, a special horn-reflector antenna was used. Previously perfected by Bell Laboratories for microwave radio relay, it is virtually immune to common radio "noise" interference. The amplifier—also a Laboratories development—was a traveling wave "maser" with very low noise susceptibility. The signals were still further protected from noise by a special FM receiving technique invented at Bell Laboratories.

"Project Echo" foreshadows the day when numerous man-made satellites might be in orbit all around the earth, acting as 24-hour-a-day relay stations for TV programs and phone calls between all nations.

This experiment shows how Bell Laboratories, as part of the Bell System, is working to advance space communication. Just as we pioneered in world-wide telephone service by radio and cable, so we are pioneering now in using outer space to improve communications on earth. It's part of our job, and we are a long way toward the goal.



Giant ultra-sensitive horn-reflector antenna which received signals bounced off the satellite. It is located at Bell Telephone Laboratories, Holmdel, New Jersey.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT

28 October 1960, Volume 132, Number 3435 SCIENCE

CURRENT PROBLEMS IN RESEARCH

Photoperiodism in Plants

Growth is controlled by light and the measurement of night length through reversible reactions of a pigment.

H. A. Borthwick and S. B. Hendricks

Flowering of plants depends upon the length of the night. Barley, wheat, and many other small grains bloom in early summer in response to short nights, while the later-maturing maize, soybeans, and chrysanthemums are induced to bloom by the longer nights of midsummer and autumn. This control of flowering is one of the methods of adaptation of species by which an unfavorable season is anticipated. It implies a time-measuring system that distinguishes between light and darkness through mediation of a pigment. Ways of finding the pigment and explanations of some of the features of seasonal response are described in this article.

First we give a partial explanation of the control mechanism, as a guide to understanding the seemingly odd methods used to find the explanation of seasonal response. The pigment, now called phytochrome, is a blue or a bluish-green protein that exists in two forms interconvertible by light, thus,

$$P_{660} \underset{730\ m\mu}{\overset{660\ m\mu}{\rightleftharpoons}} P_{730}$$

with 660 and 730 mμ the absorption maxima of the two forms. Form P_{730}, which is enzymatically active, changes in darkness to the inactive form P_{660} in the course of some hours, and the rates of the change and of the enzymatic action are essential factors in the plant's measurement of night length. The enzymatic reaction controlled by P_{730} also affects many aspects of plant growth besides flowering and results in a general control of growth by light. Phytochrome is present to the extent of about 1 part in 10 million in many plant tissues—an amount too little to give a noticeable color to leaves or stems of albino plants.

The authors are on the staff of the Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Md.

Discovery

Photoperiodism as a control of flowering was discovered in 1918 by Garner and Allard (*1*). Their first observations were on a variety of tobacco induced to flower by the combination of a long night and a short day. Garner and Allard soon found the control in many kinds of seed plants and discovered that some varieties are responsive to long nights, others to short nights. At the time, these findings had a very great impact upon students of plant growth, who had widely held, without serious questioning, that the seasonal controls must depend upon the obvious changes in temperature. Garner and Allard also pointed out the close similarity in seasonal responses of animals and plants and suggested, on the basis of its general features, that bird migration, too, is photoperiodically determined, as was later shown to be the case for several species.

Germination of many kinds of seeds also depends upon light through the mediation of phytochrome (*2*). The need for light was recorded by Caspary in 1860 for seeds of *Bulliarda aquatica* (L.) DC. (= *Tillaea aquatica* L.) and was widely studied for many kinds of seeds in the ensuing century. In nature, the light requirement, which can be just a fraction of a second of sunlight, aids in preserving the species by insuring the prolonged dormancy of a store of seeds held in darkness through accidental covering with soil. This retention of viability by seeds is a plague to farmers and gardeners who expose them to light in cultivating, to germinate and grow as weeds.

The changes in length of stems, leaves, and other plant parts which occur in plants grown in subdued light or darkness, which are other manifestations of the action of phytochrome, must have been known to primitive man. In nature, the shoot from a deeply planted seed elongates until the food reserves are exhausted or until it reaches the surface and is exposed to light, which inhibits further lengthening. Plants growing in darkness are long and limber, but given just a little light, as from a 50-watt lamp at 1 meter for 1 second, they will be shorter and will stand upright. In 1929 Robert Bridges, the poet laureate, was moved to write in his *Testament of Beauty* (*3*):

> and haply, if the seed be faln in a place of darkness
> roof'd in by men—if ther should be any ray or gleam
> how faint soe'er, 'twil crane and reach its pallid stalk
> into the crevice, pushing ev'n to disrupt the stones.

Possible interrelations of these several responses and of autumnal leaf drop, orientation of leaves in darkness, and root enlargement and bulb formation were not generally suspected, although the possibility of such interrelationships was apparent to Garner and Allard, who were also aware of many varied displays of photoperiodism in both plants and animals. Knowledge of each response was at first restricted to its occurrence among plant species

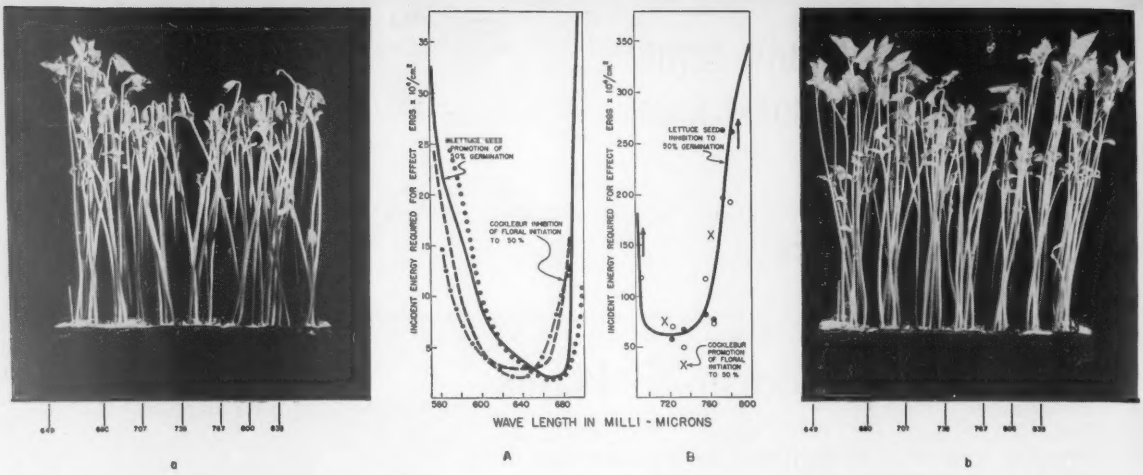


Fig. 1. Effects of radiation in the region of 560 to 850 mμ on plant growth. (*a*) Effects of a short period of irradiation in the region of 650 to 850 mμ on stem elongation, plumular hook unfolding, and leaf expansion in dark-grown red kidney bean seedlings. (*A*) Action spectra for a short period of irradiation to promote germination of lettuce seeds and inhibition of floral initiation in cockleburs: (dotted curve) enhancement of elongation of a pea leaf (by 45 percent); (dot-dash curve) the promotion of flowering in barley. (*B*) Action spectra for inhibition of germination of lettuce seeds and enhancement of floral initiation in cockleburs. (b) Effects of irradiation on dark-grown red kidney bean seedlings under conditions similar to those of (*a*) except that plants were first exposed to radiation in the region of 660 mμ prior to the short exposure across the spectrum.

and was systematized in works restricted to one type of response. Interest in possible causes for the control of growth by light was almost entirely speculative because of lack of experimental leads and of the rather natural tendency of observers to concern themselves more with the display—the flowering or the germination, for example—than with the causes. The first stirrings toward understanding actually came quite early, from findings on the dependence of etiolation upon light intensity (Batalin, 1871) and color (Vogt, 1915). By 1952, red light was known to be most effective in influencing most of the responses (*4*).

Action Spectra

Knowledge and understanding of the causes of the several responses have come from measurements of action spectra. The direct result is the finding that all the responses depend upon radiant energy and wavelength in the same way. Barley and cocklebur, representatives of plants requiring short or long nights, respectively, for flowering, have identical action spectra for the opposite responses of flowering in the former and inhibition of flowering in the latter. Although the control of flowering is not fully understood, these action spectra indicate that the mechanism is identical for the two types of plants. An even more surprising result is that this identity of action spectra is found in studies of control of stem lengthening and seed germination (Fig. 1) (*4*).

The action spectra have two parts, one for potentiating a response and the second for nullifying it (*2, 5*). Radiation in the region of 540 to 695 mμ, with a maximum near 660 mμ, potentiates the flowering of barley, the germination of lettuce seeds, the enlargement of a pea leaf, the suppression of flowering in cocklebur, and the inhibition of lengthening of the pea stem. These potentiated responses are reversed before actual responses can occur by radiation in the region of 695 to 800 mμ. The reversals, which can be repeated many times, and the near identities of the action spectra for both promotion and reversal of the various responses on an *absolute* scale of incident energy, indicate an action of light that affects many aspects of plant growth.

The identity of the action spectra has several interesting corollaries. The action depends upon the extent of the interconversion of the phytochrome forms, and, in fact, the length of a bean stem can be controlled by applications of radiant energy (Fig. 2). If the light is intense and of mixed wavelength (white), like sunlight, an equilibrium at an intermediate pigment conversion is soon attained, the position depending upon the energy distribution in various spectral regions of the source but not upon the intensity. The pigment system can be driven to the same position by light from a flashlight or by full sunlight, with similar effects upon growth. Because the pigment changes form, conversion cannot be more than complete. Radiation from a red or a far-red source, which drives the interconversion toward completeness in one direction, can be counteracted by a low reversing irradiance.

At this stage of understanding, which was reached by 1952 (*2, 5*), the objectives of isolating the pigment and of finding its mode of action seemed attainable. Progress toward objectives of this type usually depends upon development of a bioassay. But the probability that the pigment was a protein made reintroduction of extracts into living plant tissue seem unpromising. A more promising approach was to attempt to detect the pigment in vivo by physical methods which might be used for assay. The first approach was an attempt to obtain fluorescence of light, which can be detected at extremely low intensities, but none was found. Another approach was to search for plants with a high concentration of phytochrome, as might be evident from a blue or a bluish-green color of albino or etiolated tissue in which only small amounts of obscuring chlorophyll are present. Results again were negative, as were the re-

sults in studies to determine whether the pigment might be related to some known type of biologically active compound such as the bile pigments and the pigments of blue-green algae.

Physiological Characteristics of Phytochrome Action

Continued physiological studies were more encouraging. These indicated that the absorption coefficients of both forms of phytochrome and the relationship between their degree of interconversion and their physiological response could be found from the reversibility effect of light (*6*). In a first-order reaction—indicated by a measured temperature coefficient of 1.0—the rate of change of pigment concentration [*P*] with incident energy *E* (einstein units/cm^2 or 6.02×10^{23} quanta/cm^2) is

$$\frac{d[P]}{dE} = -k\,[P_o]\,(1 - F)$$

where *F* is the fraction of the pigment converted and is given by $F = \alpha\,\phi\,\chi \cdot E_{\text{incident}}$.

In the last expression P_o is the amount of phytochrome in a square centimeter of the test object, α is the molar absorption coefficient, ϕ is the quantum efficiency of the change, and χ is the fraction of incident light reaching the pigment. If the change is reversible, a similar first-order differential equation expresses the reverse change, and the two equations can be solved to give the degree of pigment conversion that corresponds to various degrees of physiological response and the value of $\alpha\,\phi\,\chi$ for the two pigment forms. In this way, α was found to be of the order of 10^5 square centimeters per gram molecule for both forms of phytochrome; this means that both forms are as intensely colored as chlorophyll and most dyes.

The small degree of change (of the red-absorbing form P_{660} to P_{730}) required to produce half saturation of the stem-lengthening responses of the pinto bean and leaf lengthening of peas indicated that P_{730} is probably the physiologically active form and is an enzyme and, accordingly, a protein. That P_{730} is an enzyme had first been suspected from the fact that many seeds in which P_{660} is present can lie in the soil for years without germinating and ultimately without respiring. Exposure to light for a few seconds, which changes P_{660} to P_{730}, causes resumption of respiration and leads to germination. The facts that most seeds that require light to germinate are small, implying reserves of fat, and that one of the first evident changes in the germinating seeds is the conversion of fat to starch give additional support to the supposition that P_{730} is an enzyme and possibly one involved in fat conversion.

The requirement for light in the reddening of apples had been known for centuries to some horticulturists, who used light to deepen the color of the fruit and to apply designs with masking stencils. The effective regions of the spectrum, however, were not known even as late of 1956. Upon study, synthesis of anthocyanin, the red pigment in the apple skin and many other plant tissues, was found to take place with light in the region of 550 to 750 mμ (*7*, *8*), although the action spectrum was not limited to this region. The amount of anthocyanin ultimately formed was linearly dependent upon the radiant energy after an induction period of one or two hours. In several objects (milo seedlings, for example) formation of anthocyanin can be reversibly controlled for several hours after being potentiated. The action spectrum for the reversal is identical with that for photoperiodism, and the energy requirements for half conversion of phytochrome and for the reversal are also identical. The high energy requirement for the initial potentiation, however, could not be explained until the action spectrum was found to depend upon a combination of the absorption spectra of the two forms of phytochrome in the spectral region where both forms absorb, as is particularly evident for red cabbage seedlings (Fig. 3) (*7*). From this knowledge the concentration of phytochrome in the seedlings could be estimated; it was found to be of the order of $10^{-7}M$ in a favorable object. It was possible to make the estimate because the anthocyanin formed by the action of a measured amount of incident radiation could be extracted and the amount (in gram molecules) established by analysis.

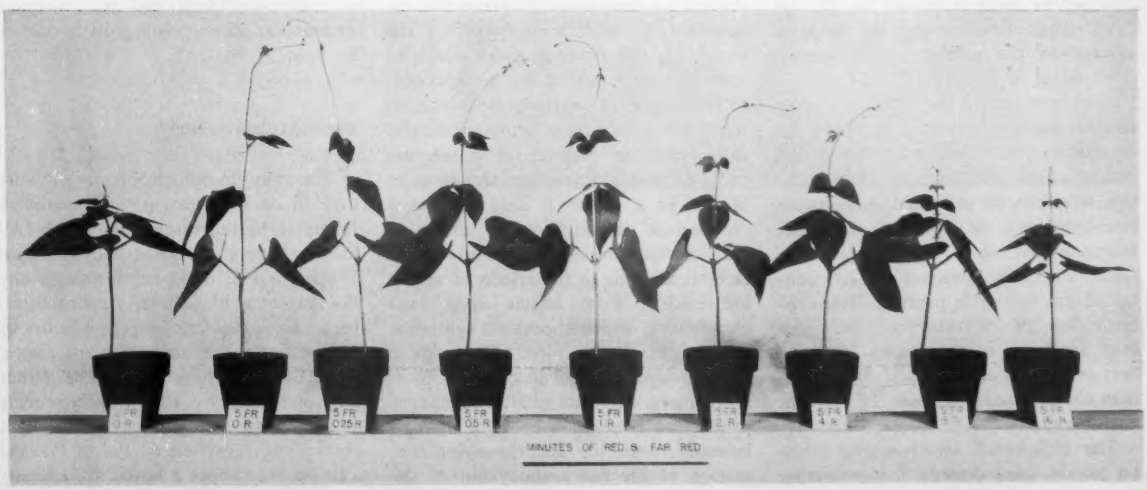


Fig. 2. Changes in internode lengths of pinto beans, induced at the end of the 8-hour day. The control plant on the left received no supplementary radiation. The other plants were exposed to far-red radiation for 5 minutes and then to red radiation for 0, 0.25, 0.5, 1, 2, 4, 8, and 16 minutes, respectively.

Detection of Phytochrome by Differential Spectrophotometry

It was a logical and intuitive conclusion from the experimental observations upon growth, germination, and flowering that phytochrome could be detected in tissue by "adequately" sensitive spectroscopic methods. The difficulty, however, was with "adequately," for the method would have to be sensitive to a change in the light transmitted by the tissue of the order of one part of the incident light in 10^6 parts, and it would have to be applicable to highly scattering media. K. H. Norris and his associates, of the Agricultural Marketing Service, U.S. Department of Agriculture, designed and built a simple differential spectrometer having the required sensitivity, for use in measuring the ripening of fruits (*9*). The instrument is similar in principle to the double-beam differential spectrometer developed by Chance (*10*) for following the changes of respiratory pigments in living tissue. Through use of the instrument of Norris *et al.*, values of Δ in Δ (Δ O.D.) = [(O.D.$_{660}$ − O.D.$_{730}$) after irradiation in the region of 660 mμ] − [(O.D.$_{660}$ − O.D.$_{730}$) after irradiation in the region of 730 mμ] can be obtained as phytochrome is changed from P_{660} to P_{730} or from P_{730} to P_{660} (*11*). An adequately stable single-beam spectrophotometer suitable for use with highly scattering media also was available. The change in optical density in shoots of dark-grown seedlings of maize with wavelength of light as phytochrome is changed in form is shown in Fig. 4*a* (*11*). This curve reflects the features evident in the several action spectra for control of growth (Fig. 1).

We now had the desired assay method for phytochrome, provided the reversibility with light was effective on broken tissue. Fortunately, clear aqueous solutions of extracted nonparticulate cytoplasm of etiolated maize responded reversibly. Protein fractions salted out of the aqueous extracts contained the reversible pigment. The concentration of phytochrome has now been increased to more than 20 times that of the first extract by H. W. Siegelman, who used methods of protein chemistry.

The differential spectroscopic method can be used directly for estimating the concentration of phytochrome in living tissue having low chlorophyll concentrations. Phytochrome is detectable, for example, in cauliflower and artichoke florets, in avocado and Zucchini squash fruits, and in etiolated tissue of many seedlings of grasses and cotyledons of several members of the cabbage family. It has been detected in extracts of spinach leaves, but the reversible change was not detected in extracts of cocklebur and soybean leaves known to be photoperiodically responsive.

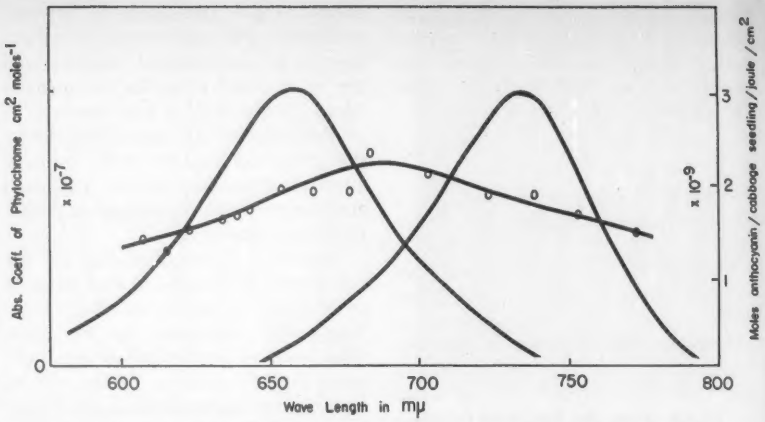


Fig. 3. Variations with wavelength of molecular extinctions of the two forms of phytochrome and the action spectrum for the formation of anthocyanin in red cabbage.

The separated phytochrome is the active principle of photoperiodism and related plant-growth phenomena controlled by light. The properties in solution are those foretold by the physiological responses. In solution, however, neither P_{660} nor P_{730} undergoes spontaneous change to the other form. As would be anticipated, the extracts, even though photoreversible, apparently lack some of the factors necessary for the enzymatic activity of P_{730} with which its reversal in darkness to P_{660} is associated.

The entry of phytochrome into so many aspects of plant growth indicates that P_{730} is an enzyme for a reaction common to many reaction sequences in plants. In a sense, it may control a "bottleneck" through which much of the material for plant growth must pass. Several clues as to the region of action are evident from effects upon seed germination and anthocyanin synthesis, but a further one is most telling. Apple skins produce ethanol in darkness from sucrose as a substrate (*12*). The ethanol production is stopped by light of high intensity, with the accompanying formation of the red anthocyanin of the skin. This indicates that the essential light reaction controls the fate of a two- or three-carbon compound, permitting its passage either to ethanol or, through condensation, to an aromatic compound.

A reasonable, but entirely speculative concept, is that the reaction is closely associated with reactions of acyl coenzyme A compounds which are known to be essential for fat utilization and formation (seed germination), the operation of the Krebs cycle, and anthocyanin and sterol syntheses. In fact, regulation of acetyl coenzyme A levels is an ideal control for growth because more than three-fourths of the carbon of a plant is incorporated in acetyl coenzyme A at some stage of passage (*13*). The purpose of these comments, which are speculative, is to indicate that a single specific type of reaction, not too difficult to demonstrate experimentally, can well lead to the many spectacular displays of growth control by light.

Time Measurement

The way in which plants measure time in darkness can now be outlined. Essential to the discussion is the fact that, in plants irradiated with red light at the onset of darkness to change any P_{660} present to P_{730}, the phytochrome reverts to the P_{660} form within 4 hours of darkness. In the several plants upon which measurements were made, either physiologically by following flowering or physically from the change in light absorption, reversion of P_{730} to P_{660} has a half-life of about 2 hours. If the half-life is constant, P_{730} will be reduced to $(\frac{1}{2})^5$, or to 3.1 percent, of its initial activity after 10 hours in darkness. This

is the approximate critical length of night for control of flowering of plants requiring either long or short nights for induction.

While change of P_{730} to P_{660} in darkness is essential for flowering of photoperiodically responsive plants, it is not the only controlling factor. The metabolic reserves also are time-dependent. These reserves are built up as simple sugars, polysaccharides, starch, and fatty acids through photosynthesis during the day and are utilized at night in systems of reactions, including those controlled by the P_{730} form of phytochrome. In short, the decreasing amount of P_{730} depends for action upon reserves that decrease with time.

Endogenous rhythms are a third pertinent feature of change in plants and animals during darkness. These rhythmic changes have been studied extensively by E. Bunning, of the University of Tübingen, who has implicated them in the timing of photoperiodism (*14*, *15*). They have been the subject of a recent symposium on "Biological Clocks" (*16*), in which their importance for time sensing by animals was emphasized. A feature of an interconnected system, be it mechanical, hydraulic, electrical, financial, or biochemical, is that a disturbance of input tends to produce oscillations of the output. The frequencies of the oscillations depend upon coupling constants of the system and the degree of entrainment by the disturbance.

The rhythms of biological objects, which are referred to as "circadian" rhythms, generally complete a cycle in about 24 hours. This cycle length is

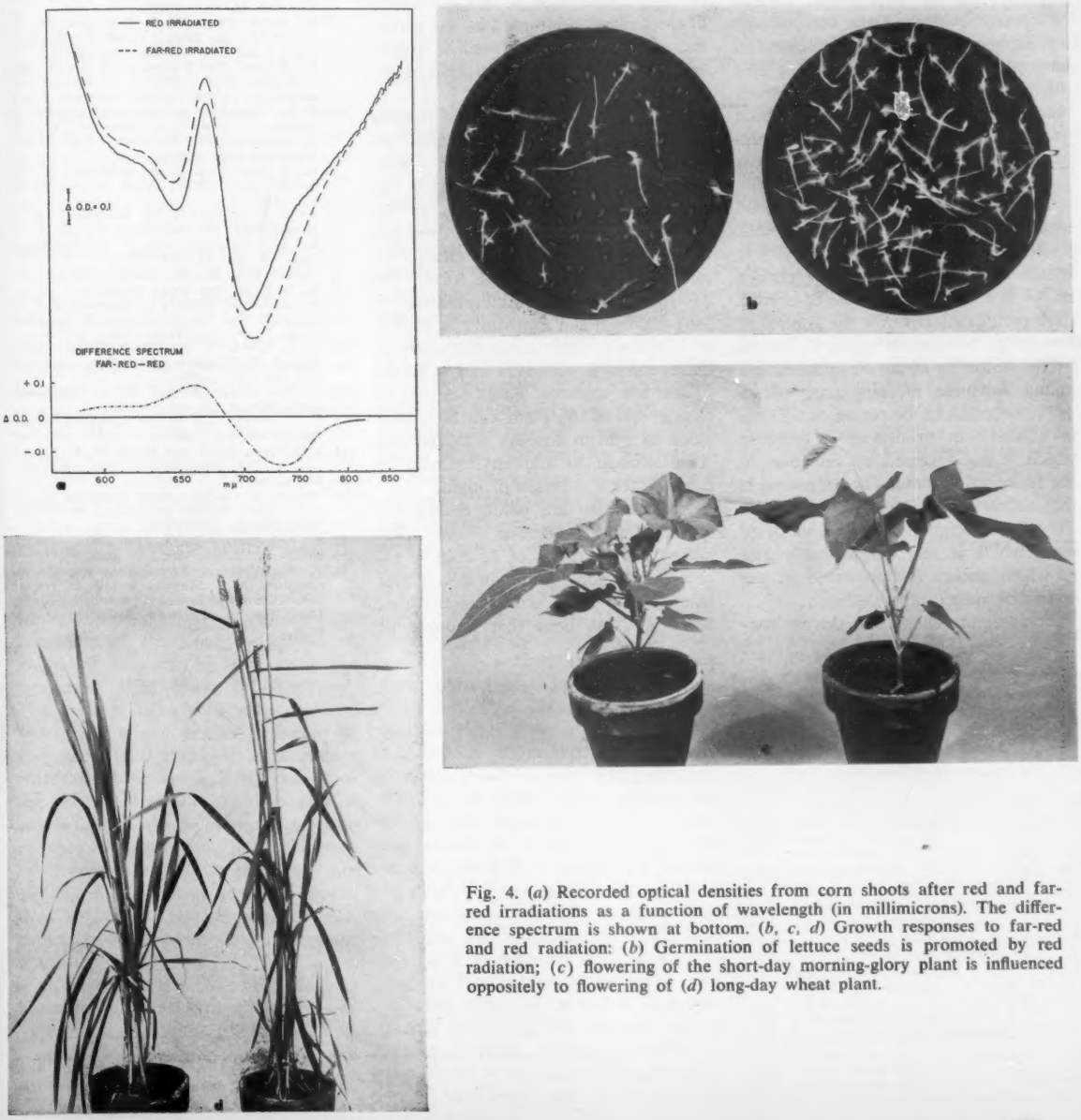


Fig. 4. (*a*) Recorded optical densities from corn shoots after red and far-red irradiations as a function of wavelength (in millimicrons). The difference spectrum is shown at bottom. (*b*, *c*, *d*) Growth responses to far-red and red radiation: (*b*) Germination of lettuce seeds is promoted by red radiation; (*c*) flowering of the short-day morning-glory plant is influenced oppositely to flowering of (*d*) long-day wheat plant.

indicative of the evolutionary origin of the process, locking together the rhythm and the change of day and night. The activity cycles of animals in continuous darkness indicate that the periods of the cycle are endogenous, or "free-running" (*15*). The degree to which the rhythms are "free-running" in plants, however, is difficult to assess.

In plants, the initial disturbances upon entering darkness are so great and the times of marked change are such large fractions of the dark period as to cause entrainment of endogenous periods. Only after the entrainment is lessened can the endogenous rhythm be clearly evident. Data on periodic leaf movement and flowering control in long periods of darkness suggest that this lessening of the initial disturbances reaches critical values only after about 16 hours, a period longer than the natural night in regions where most plants grow.

Another finding, the significance of which is by no means clear, is that photoreversibility of flowering is lost within less than an hour after change of P_{660} to P_{730} near the middle of normal dark periods effective for the control of flowering. In extreme cases, illustrated by the flowering of lamb's-quarters and young Japanese morning-glory plants (*17*), radiation in the region of 660 mμ is effective in producing a response which is not reversed by radiation in the region of 730 mμ. The suggestion is that conversion of P_{730} is quenched, possibly by association with the substrate upon which it acts enzymatically and to which energy is transferred in the course of anthocyanin synthesis.

Temperature changes in the environment also influence many aspects of plant growth, as has been emphasized in particular by F. W. Went of the Missouri Botanical Garden (*18*). That all components of change in an interconnected system should be temperature-dependent is expected. The change in output, however, can be compensated by interconnections of components to achieve an approximate constancy, once the transient of initial change has passed. This is in accord with both the slight change of endogenous rhythms with temperature and the induction of many growth responses by temperature change. An illustration of the control is afforded by the germination of many seeds which require both variation of temperature and exposure to light.

The emphasis placed on the reasons for responses to light has diverted attention from many displays of photoperiodism and striking controls of growth. One of the displays is the dormancy of terminal buds of trees and other woody plants, which affects annual growth and eventual form. The cessation of growth is usually induced by long nights. It can sometimes be broken by a return to short nights but often requires removal of leaves and a period of low temperatures. These features of change within the plant can be understood as synchronization with the seasonal change of the environment in temperature and length of night.

Animals also are photoperiodic for reproduction, migration, and dormancy. Comparisons of descriptive aspects of photoperiodism in plants and animals show many striking similarities. Some workers hold that endogenous rhythms are the basic common causative feature. In keeping with the developments discussed above, however, the working hypothesis is that a common reaction may underlie the endogenous rhythms and the photoperiodic responses. A need exists both for many more studies of plants and for studies of cause rather than display in animals. Even if causes for plants and animals prove to be unrelated, it would be interesting to find in what ways similar ends are achieved.

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Identifying Significant Research

Literature citation counting is evaluated as a means for identification of significant research.

J. H. Westbrook

There has been a tendency in recent years to measure the scientific performance of laboratories, individuals, and journals by simply counting the number of papers published (*1–4*). While it is no doubt true, as Fisher (*4*) has maintained, that such a count is a reasonable measure of scientific *activity*, it gives little indication of the *quality* or *significance* of that work. Not only do both laboratory publication policies and journal acceptance standards vary widely, but work on a trivial problem may be so performed and so described as to meet even the highest standards of publishability and yet have no marked significance, either permanent or transitory.

How, then, does one distinguish, on an objective basis, the brilliant research paper from the marginally acceptable, the trivial from the significant piece of work? This study (*5*) explores the possibility of measuring the quality of published research by examining the references cited in published papers. The concept of a publication citation parameter is not novel. Various investigators have employed it heretofore with this objective (*2, 3, 6*) as well as for other purposes (*7*). The present article is a more extensive examination of the approach than has previously been reported. Furthermore, by employing citations from research papers, it is not, as is Lehman's analysis (*2*), subject to the inherent bias of a single authority.

For a definable subject field, study of literature citations attributable to a certain source rather than study of the published papers emanating from that source offers the advantage of a process of natural selection. That is, provided the sample is large enough for the derived results to be statistically significant, repeated citation of a particular source by independent research workers whose own contributions have met some standard of publishability is very probably indicative of the worth of the scientific output of that source (*8*). In principle, it is believed that with this parameter—the number of literature citations—it should be possible to identify laboratories, individuals, or even specific papers of unusual significance, provided only that the sample size be adequate. In the present study, attempt is made by this means to identify *laboratories* that are doing the most significant work. The subject field was limited to ceramics by reason of my previous experience and current interest, but it is believed that the approach is of more general applicability.

It will be demonstrated that this method yields a useful measure of the significance of research. Two shortcomings must be acknowledged, however, at the outset. First, science, like many other fields, is subject to changing fashions of interest which may lead in this case both to a distorted number of published papers in a given subject and to an inordinately high level of citations for a laboratory which happens to have been one of the first working on the fashionable subject. This difficulty could be overcome in principle by extending the analysis over a period of years. A second problem is that there is no means for appraising work performed but not published, either for proprietary reasons or simply because publication is not encouraged by the laboratory in question. However, as Fisher (*4*) points out, this may not actually be a serious difficulty, at least for basic research, because of the strong motivation for research scientists to gravitate to laboratories with a liberal publication policy.

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The Sample

Two populations were chosen for analysis: the references cited in the 99 papers published in the 1958 *Journal of the American Ceramic Society*, hereafter called population *A*, and a composite group of papers bearing on ceramics, chosen from the respective volumes for 1958 of *Acta Metallurgica*, the *Journal of Applied Physics*, the *Journal of the Physics and Chemistry of Solids*, the *Journal of Physical Chemistry*, and the *Journal of the American Chemical Society*—a group of references hereafter called population *B*. The details of the method for selecting papers for this latter population are given below. In both cases, "Letters to the editor" and "Notes" were considered as well as full research papers.

Table 1. Counts for all population *A* source laboratories having five or more net citations.

Rank	Source	Citations (No.)	
		Gross	Net
1	National Bureau of Standards	93	45
2	Geophysical Laboratory	37	36
3	Massachusetts Institute of Technology	31	29
4	University of Sheffield	24	24
5	Pennsylvania State University	47	22
6	General Electric Company	25	19
6	University of London	19	19
8	University of Illinois	17	13
9	Ohio State University	15	12
10	N. V. Philips (Eindhoven)	10	10
11	Bell Telephone Laboratories	9	9
12	Alfred University (N.Y. State College for Ceramics)	19	8
12	University of California	11	8
12	Carnegie Institute of Technology	8	8
12	Eastman Kodak	8	8
12	Max Planck Institute (Berlin)	8	8
17	Battelle Memorial Institute	8	7
17	Cambridge University	7	7
17	Corning Glass Works	8	7
17	General Electric Co., England	7	7
17	University of Göttingen	7	7
17	Oak Ridge National Laboratory	10	7
23	University of Chicago	6	6
24	Raytheon Electrical Manufacturing Co.	5	5
24	United States Steel	5	5
24	Westinghouse	5	5

Table 2. Provenance of published papers, population *A*.

Source laboratories	Published papers in sample (No.)
Pennsylvania State University	10
National Bureau of Standards	9
Alfred University	7.5
University of Illinois	5
General Electric	4
Ohio State University	4
University of Utah	4
Corning Glass	3
Oak Ridge National Laboratory	2
Owens-Illinois Glass Company	2
Portland Cement Association	2
Clemson University	2
A. O. Smith	2
Mellon Institute	2
Raytheon	2
Armour Research Foundation	2
Hanford Atomic Power Laboratory	2

It was necessary to eliminate certain types of references from the total before beginning the detailed identification and analysis of the citations to avoid duplicate publications and to ensure a minimum scientific standard. Such groups as private communications, internal reports, government contract reports, theses, reference works, and monographs were therefore eliminated. Aside from recognized scientific journals, the only accepted references were references to the proceedings of special symposia, which are frequently published separately from the usual journals although sponsored by competent scientific bodies.

Procedure

The 838 references remaining in population *A* after the discards described above had been made were put on punch cards, together with notation of the parent article and journal, and punch-indexed accordingly. (The cards prepared by the *American Society for Metals* for literature-filing purposes proved to be convenient and easily adapted for this use.) The affiliation of each author of each cited reference was then determined and noted on the face of the punch card, and this information was also indexed. Insofar as possible, identification was made by consulting the cited journal directly. Where this proved to be impossible, recourse was made to *Chemical Abstracts* or, in a few cases, to biographical works such as *American Men of Science* and its foreign counterparts. Particular care was taken to identify the laboratory at which the work was done rather than the affiliation at the time of publication or the permanent affiliation of the author. It was not possible to identify the source of 100 percent of the cited references. However, in the case of population *A*, only 27 references (or slightly more than 3 percent) remained unidentified. A similar degree of success was achieved with population *B*; in no case did the percentage of unidentified citations from a single journal exceed 5 percent.

The identified citations were next sorted as to source laboratory. It was found that the 811 identified citations in population *A* represented 213 laboratories. It was considered necessary at this point to reject certain citations from the identified population. First, all citations were rejected whose laboratory attribution was the same as that of the source article. Such elimination of what I will designate "in-house" citations is a conservative and perhaps (as will be seen) unnecessary step, but one which serves to increase the objectivity of the analysis. After this, a few more citations were rejected when it was found that the author referred to his own work performed at an institution with which he had previously been affiliated. The 660 cards remaining after elimination of these "self citations" were designated "net citations."

Table 3. Representative titles of source articles in population *B*.

J. Appl. Phys.
"Nucleation and growth in a photosensitive glass"
"Magnetic susceptibility of neutron irradiated quartz"

J. Phys. and Chem. Solids
"Hall effect and electrical conductivity of transition metal diborides"
"Deviations from stoichiometry in binary ionic crystals"

J. Phys. Chem.
"Reduction of contaminated rutile surfaces by degassing"
"Hydrothermal reactions between calcium hydroxide and amorphous silica"

J. Am. Chem. Soc.
"The preparation, lattice parameters, and some chemical properties of rare earth mono-thio oxides"
"The stoichiometry of the hydration of beta-dicalcium silicate and tri-calcium silicate at room temperatures"

Acta Met.
"Dislocation patterns in potassium chloride"
"Precipitation of magnetite in the sub-structure boundaries of an iron protoxide rich in oxygen"

Table 4. Counts for all population *B* source laboratories having five or more net citations.

Rank	Source	Citations	
		Gross	Net
1	Bell Telephone Laboratories	45	31
2	National Bureau of Standards	21	21
3	University of London	20	20
4	University of California	20	19
4	University of Chicago	20	19
6	General Electric Company	30	18
7	University of Göttingen	17	17
7	Harvard University	17	17
7	Massachusetts Institute of Technology	20	17
10	N. V. Philips (Eindhoven)	15	15
11	University of Cambridge	15	14
11	Oak Ridge National Laboratory	25	14
13	University of Bristol	21	13
13	Max Planck Institute (Stuttgart)	13	13
15	Carnegie Institute of Technology	12	12
15	University of Grenoble	12	12
17	Oxford University	11	11
18	Westinghouse	15	10
19	University of Amsterdam	9	9
19	Naval Research Laboratory	9	9
19	University of Turku, Finland	18	9
22	Cornell University	8	8
22	University of Illinois	11	8
22	Pennsylvania State University	10	8
25	Battelle Memorial Institute	7	7
25	Columbia University	7	7
25	University of Oslo	7	7
28	University of Danzig	6	6
28	General Electric Co., England	8	6
28	National Research Council, Ottawa	6	6
28	University of Pittsburgh	6	6
28	Purdue University	6	6
28	Siemens and Halske	6	6
28	United States Bureau of Mines	25	6
35	University of Birmingham, England	5	5
35	Eastman Kodak	5	5
35	Institute of Inorganic Chemistry, Kiev	5	5
35	University of Jena	5	5
35	University of Manchester	5	5
35	Stanford University	5	5

Results, Population A

Table 1 lists the counts for all source laboratories having five or more net citations. The top ten sources account for almost 30 percent of all identified citations, although they represent less than 5 percent of all sources in the population. Inspection of the data in column 3 (headed "Gross citations") reveals that if the in-house and self citations had not been eliminated, the top ten source laboratories of population *A* would have been almost exactly the same; the order of rank is changed only in a minor way.

It is of interest to examine the

sources of the parent papers which provided the references of population *A*. Sixty-five papers are represented by the sources shown in Table 2; each of the remaining 34 papers came from a different source. Comparison with Table 1 shows that six of the laboratories appearing in Table 2 are also among the top ten sources in Table 1. The worth of the comparison is obviously lessened somewhat by the fact that the references cited in the sample must be of an earlier date than 1958, the year in which the parent papers were published. To obtain specific information on this point, the number of citations per calendar year was obtained for all identified citations; the results are plotted in Fig. 1. One immediate consequence of this result is the finding that the modal year, 1956, might be a more meaningful year than 1958 if a comparison is to be made between the numerical leaders in publications and the leaders with respect to citations (*9*). However, marked changes in the character or standing of a given laboratory are unlikely to occur in as short a time as two years. To identify the point in time to which our measures refer is an elusive problem. The work represented by the modal year of citation (1956) was probably submitted for publication in 1955 and performed in 1954.

Results, Population B

Population *B* was made up, so as to conform in size to population *A*, of 100 papers on ceramics—20 from each of the 1958 volumes of the journals cited above. It will be noted that there are represented two physics, two chemistry, and one metallurgical journal.

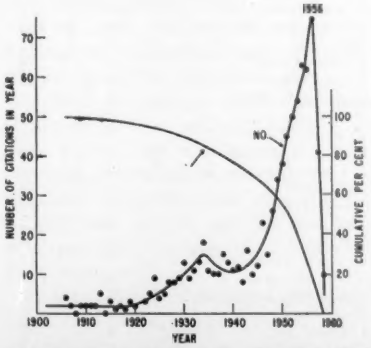

Fig. 1. Year of publication of papers cited in 1958.

Table 5. Breakdown by journals of net citations for population *B*.

Laboratories	Net citations (No.)					Total
	Acta Met.	*J. Phys. and Chem. Solids*	*J. Appl. Phys.*	*J. Am. Ceram. Soc.*	*J. Phys. Chem.*	
Bell Telephone Laboratories	4	15	7	3	2	31
National Bureau of Standards	1	1	2	13	4	21
University of London	4	0	0	7	9	20
University of Chicago	4	3	3	4	5	19
University of California	1	1	1	4	12	19
General Electric	11	3	2	1	1	18
University of Göttingen	1	13	1	0	2	17
Harvard University	4	6	3	1	3	17
Massachusetts Institute of Technology	6	2	4	0	5	17
N. V. Philips (Eindhoven)	0	11	1	0	3	15

Since in contrast to the source journals for population *A*, these journals publish over a wide range of pure and applied science, it was necessary to adopt a definition of the term *ceramic research* to aid in selecting papers to make up the sample. For the purposes of this analysis a broad definition was chosen—namely, all nonmetallic inorganic materials and all metallic compounds. While many will quarrel with this definition, it permits inclusion of work on graphite, on carbides and other interstitial compounds, on alkali halides, and on intermetallic compounds, all of which are subjects of great current activity in ceramics laboratories throughout the world. In general, the first 20 papers from each journal were chosen. Representative titles of papers thus selected are given in Table 3; these should serve to indicate the pertinence to the subject field of these source journals and of the papers selected therefrom.

According to the procedures used for population *A*, 949 gross identified citations were obtained from an original gross of 998 indexed references in population *B*. Table 4 lists gross and net counts for all sources from population *B* having five or more net citations. The top ten sources yield 20 percent of all identified citations, although they comprise less than 5 percent of all sources in the group. On comparing Table 4 with Table 1 it may be noted that five laboratories appear near the top of both lists: National Bureau of Standards, University of London, General Electric, Massachusetts Institute of Technology, and N. V. Philips. This result would seem to imply that the two populations are rather similar but nonetheless possess certain differences. Table 5 presents some figures on net citation breakdown by journals for the leaders in Table 4, figures which show the predilection of some laboratories for certain publication media.

Analysis of the attribution of the source papers of population *B* is made in Table 6; these data may be compared with the analogous data for population *A* in Table 2. The 17 sources shown in Table 6 represent 56 papers; 44 other laboratories contributed one paper each to the sample population. The fact that only three laboratories are common to Tables 2 and 6 is indicative of a difference between the two populations, perhaps one of concern with fundamental versus applied science or of individual preference for particular publication media.

Additional Analyses

The analyses made thus far do not permit us to distinguish between two types of laboratories. One group is

Table 6. Provenance of published papers, population *B*.

Source laboratories	Published papers in sample (No.)
Bell Telephone Laboratories	8
General Electric	5
University of Illinois	5
Bureau of Mines	5
Massachusetts Institute of Technology	4
Oak Ridge National Laboratory	4
Westinghouse	3
University of California	3
International Business Machines	3
Radio Corporation of America	2
Concepción University	2
Brooklyn Polytechnic Institute	2
Naval Ordnance Laboratory	2
Illinois Institute of Technology	2
Du Pont	2
Tufts University	2
University of Chicago	2

typified by laboratory *X*, which produces only a few papers per year, most of which are significant. The other group is exemplified by laboratory *Y*, which produces a large number of papers annually of which only a fraction are significant; the significant papers of laboratory *Y*, however, are perhaps numerically equivalent to those of laboratory *X* simply because the sample is large enough for a wide spectrum of scientific talents to be represented. Therefore, a different, and perhaps more meaningful, comparison of laboratories engaged in ceramics research can be made by asking what *proportion* of the work done by a laboratory is significant in the sense of this study (that is, results in literature citations). Since it is essentially impossible to obtain data on the actual output of ceramics research publications for individual laboratories, the attribution of the source papers comprising the sample populations will be used as a measure of the publication output. Since the numbers with which we have to deal are small, we will combine populations *A* and *B*. We then proceed, using data previously obtained, to plot the number of citations for a given laboratory against the number of source papers attributed to that same laboratory in the 1958 populations *A* and *B* (*10*).

Table 7. Comparison of the median year of citation for some leading laboratories.

Laboratory	Net citations (No.) (populations A + B)	Median year of citation
Geophysical Laboratory	37	1924
University of Göttingen	24	1939
Harvard University	19	1940
Bureau of Mines	9	1942
Cambridge University	21	1948
Sheffield University	25	1949
Corning Glass	9	1950
N. V. Philips (Eindhoven)	25	1950
Ohio State University	16	1950
Bristol University	16	1951
Grenoble University	15	1951
University of Chicago	25	1951
Over-all (*A* and *B*)	1785	1951
University of London	39	1952
Carnegie Institute of Technology	20	1952
National Bureau of Standards	66	1952
University of Illinois	21	1952
Pennsylvania State University	30	1953
Massachusetts Institute of Technology	46	1953
University of California	27	1953
General Electric	37	1953
Bell Telephone Laboratories	40	1953
Alfred University	9	1954
Westinghouse	16	1954
Oak Ridge National Laboratory	21	1955

Table 8. Source of papers and citations, by categories, for populations *A* and *B*. Percentages in parentheses.

	Universities	Industry	Govt. agencies	Other	Total
Output of papers (*A* and *B*)	90 (45)	68 (34)	27 (14)	14 (7)	199 (100)
Distribution of gross identified citations (*A* and *B*)	1010 (57.5)	437 (25)	266 (15)	47 (2.5)	1760 (100)

It is to be expected that if a relation exists between these two quantities, it could be represented by

$$C_n = KP_n^{1/m}$$

where C_n is the number of citations, P_n is the number of papers published, and K and m are constants. This function meets two basic criteria in that it passes through the origin and increases less than linearly. The first requirement is obvious, since a laboratory that produces no papers can have no citations made to its work according to the rules followed in this analysis. The second requirement is imposed on the functional form, inasmuch as a laboratory which produces an increasingly large proportion of the total published work in a field must suffer a consequent decrease in proportion of *net* citations (by definition, in-house citations are eliminated).

Figure 2 presents such a treatment of our data. Taking arbitrary values for the constants m and K, we find that a major portion of the data points for leading U.S. laboratories falls within a band defined by a small range of values of K and with $m = 3$. Foreign laboratories were not considered since they are not adequately represented in the output parameter used. Furthermore, no points are shown for any laboratory with $\leqq 14$ net citations or $\leqq$ three source papers.

It appears from this analysis that three U.S. laboratories are responsible for an unusual proportion of significant ceramic research: the National Bureau of Standards, Massachusetts Institute of Technology and the Geophysical Laboratory. This finding, however, requires qualification. The NBS publishes a captive journal (*Journal of Research of the National Bureau of Standards*), which is the exclusive publication outlet for much of its work. Indeed, of the 66 net citations credited to NBS in populations *A* and *B*, 51 were to papers published in its own journal. No reflection on the scientific calibre of the work is implied, but these facts indicate that the figure used for publication volume of this laboratory in Fig. 2 (as well as in Tables 2 and 6) is much too low. Were it possible to correct for this difficulty, the point for NBS might well fall within the scatter band, far to the right. A similar difficulty does not arise with respect to Bell Laboratories, for only one citation out of 40 was to the *Bell Laboratories Technical Journal*.

Another sort of ambiguity attaches to deductions made from Fig. 2. Consider the case of a laboratory, prominent as a source of significant research contributions some years ago, whose volume productivity is now low. It may still receive a large number of citations because of its early work, but its current output parameter will be low. Such instances might include the Geophysical Laboratory or Carnegie Institute of Technology. Correspondingly, a very new center of research activity in the subject field might be responsible for a current publication rate which is high in proportion to the impact which these publications have thus far had as evidenced by citation counts.

Table 9. Data for the top 20 journals.

Journal	Citations (No.)	
	Population A	Population B
*J. Am. Ceram. Soc.**	216	12
*J. Am. Chem. Soc.**	29	104
Phys. Rev.	7	112
*J. Phys. Chem.**	19	54
*J. Appl. Phys.**	20	36
J. Research NBS	48	3
Acta Cryst.	17	31
Z. physik. Chem.	9	39
J. Soc. Glass Technol.	33	10
J. Chem. Phys.	10	30
*Acta Met.**	4	29
Trans. AIME	19	13
Phil. Mag.	3	26
Am. J. Sci.	26	0
Z. anorg. Chem.	7	15
Z. Physik	4	18
Trans. Brit. Ceram. Soc.	20	0
Bull. Am. Ceram. Soc.	18	0
J. Chem. Soc.	4	13
J. Inst. Metals	2	13

* Journal included in this study.

We may assess the extent to which such considerations affect our conclusions by comparing the median year of citation for a given laboratory with the median year for the whole population (1951). In the absence of factors such as those just discussed, and provided our sample size for an individual laboratory is adequate, significant deviations from the over-all median would not be expected. Deviations from the over-all median of more than two or three years are probably indicative of the influence of the suspected factors. The results of such an analysis are shown in Table 7. The apparent prominence of the Geophysical Laboratory is thus due primarily to research of 30 to 40 years ago rather than to its work in the last decade. Göttingen, Harvard, and the Bureau of Mines also appear to have been more prominent in the field some years ago than they are today. The remainder of the laboratories examined in Table 7 show median years falling very close to that for the total population. It is of interest to note that Oak Ridge, a laboratory founded during World War II, has the latest median year.

We may examine our results in yet another way. Thus far, no regard has been paid to replicate citations—that is, to those numerous instances in which the same piece of work is cited by two or more different groups of authors. Obviously such papers are of more than ordinary significance, and a laboratory responsible for a number of repeatedly cited papers is deserving of special attention. The punched cards were readily sorted to yield this information, through use of the author indexing. To obtain a larger total sample, populations *A* and *B* were again combined. The results of this analysis are shown in Fig 3. As may be noted, one paper was cited five times; two, four times; eleven, three times; and 32, two times. The results support the findings of the previous analyses, since five of the top six leaders in this analysis were also leaders in the analyses shown in Tables 1 and 4 and in Fig. 2. The highly selective nature of the replicate-citation parameter may be appreciated from the fact that the 32 papers cited two or more times represent less than 3 percent of all net citations examined.

It may also be of interest to examine the source of both papers and citations by categories. For this purpose laboratories were classified as university, industry, government, and other (*11*). These data are shown in Table 8. Here again, populations *A* and *B* were considered together; examined separately, they did not appear to give significantly different results. It would appear that the universities are responsible for a larger proportion of significant work than is indicated by their volume output of papers, as might be expected. This same conclusion is suggested by the analysis of leading individual laboratories, as shown in Fig. 2.

As a final point we might look at the journals in which the cited articles appear. Data for the top 20 journals are shown in Table 9. The numbers in column 2 indicate a rather extensive amount of "inbreeding" for the *Journal of the American Ceramic Society*. Similar breakdowns for the individual journals in population *B* were not considered feasible because of inadequate numbers. Table 9 may also be examined to assess the propriety of the choice of journals for the sample populations. The selected journals rank 1, 4, 7, 9, and 16 for population *A*, and 2, 3, 5, 8, and 13 for population *B*. The *Journal of Physics and Chemistry of Solids* did not rank among the leaders and is not considered here. It is a comparatively new journal and therefore would not be expected to rank high among the cited journals.

Conclusions

1) Analysis of literature citations is a useful measure of the significance of research. Analyses based on (i) gross number of citations, (ii) net number of citations (in-house and self citations omitted), (iii) replicate citations, and (iv) ratio of citations to papers published give results which are in general agreement.

2) The analyses discussed in this article indicate that the following laboratories are responsible for especially significant work in ceramics (although

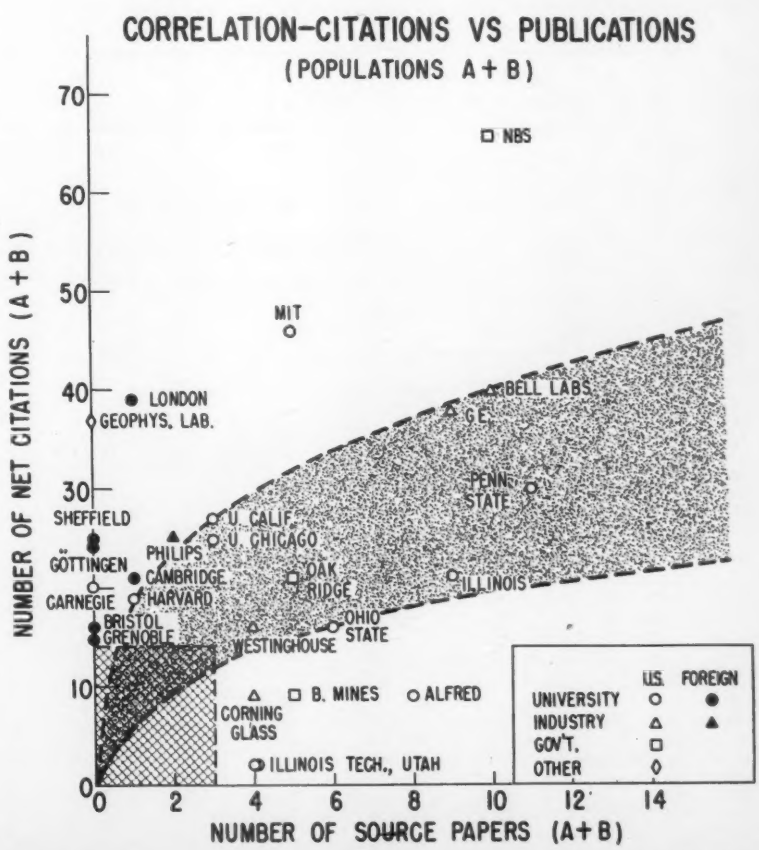

Fig. 2 Correlation of number of citations with number of publications (populations *A* plus *B*).

not necessarily in the order given): the National Bureau of Standards, the University of London, Massachusetts Institute of Technology, General Electric, Philips (Eindhoven), Geophysical Laboratory, and Bell Laboratories.

3) A sample size of 100 papers, yielding about 1000 usable, identifiable citations, is adequate for identification of laboratories doing significant research. Much larger samples would probably be required to extend this analysis—for example, to measure the performance of individual scientists or to identify unusually significant specific papers.

4) The modal year of citation for a given year of publication precedes the latter by about two years, and this difference has been approximately constant over the past 20 years.

5) An equation of the form $C_n = KP_n^{1/m}$ roughly represents the relation between the number of net citations attributed to a given laboratory and the number of its publications.

6) Universities are responsible for a somewhat larger volume of research papers in ceramic science than is industry and for a still larger proportion of significant work. Government agencies play a minor role, as compared to the other two sources, although certain individual laboratories are outstanding, as noted above.

7) Comparison of the median year of citation for individual laboratories with the median year for the whole population can give useful information on the time dependence of the relative prominence of those laboratories.

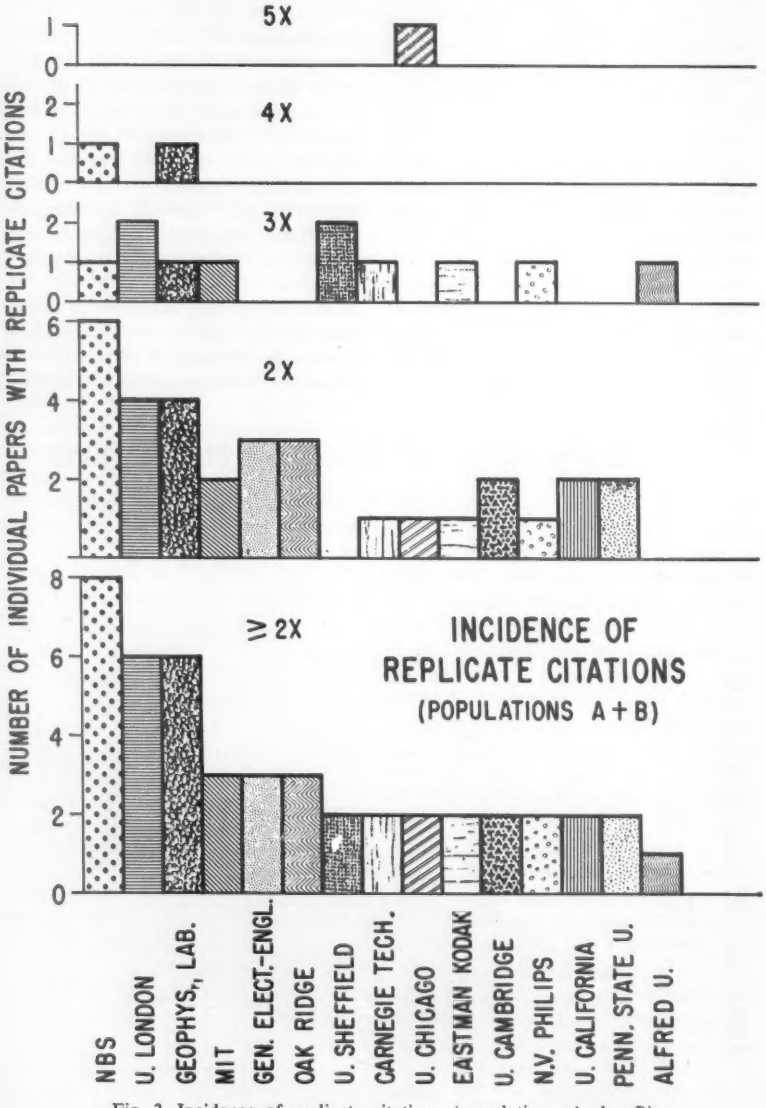

Fig. 3. Incidence of replicate citations (populations *A* plus *B*).

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5. I am greatly indebted to Miss M. L. Horrocks and to A. J. Peat for assistance in gathering and analyzing the data used in this study. I also want to thank R. C. DeVries and R. J. Charles for beneficial discussions and critical reading of the manuscript.
6. Studies by Spence, Pelz, and others are obscurely alluded to in *Proceedings* of the 1st and 2nd University of Utah Research Conferences, but no formal publication of these results has been found.
7. P. L. K. Gross and E. M. Gross, *Science* **66,** 385 (1927); L. M. Raisig, *ibid.* **131,** 1417 (1960); P. Weiss, *ibid.* **131,** 1716 (1960).
8. Rare instances may be encountered of repeated citations to an unusually poor paper which gives results so erroneous or conclusions so fallacious that many subsequent workers feel compelled to point these out and directly refute them. It is believed that these instances are so rare that they do not affect the present study.
9. Similar results were obtained for analysis of somewhat smaller samples of referenced citations taken from the *Journal of the American Ceramic Society* for the years 1953, 1950, 1948, and 1939. It had been suspected that the lag between modal year of citation and year of referencing publication might be diminishing with time, but it remains constant at about two years.
10. A separate analysis showed that a three-year average for the output parameter did not yield significantly different results.
11. The category "other" includes foundations, consulting laboratories, research institutes, and so on.

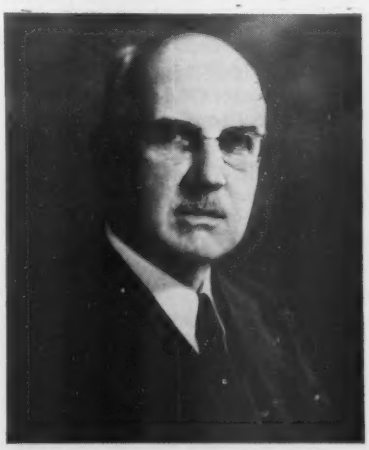
W. J. Mead, Experimental Geologist

Warren Judson Mead, who died on 16 January 1960 in his 77th year, was a distinguished geologist known for his achievements as teacher, author, and administrator; a research scientist; an engineering geologist and expert on structures, dam sites, and the behavior of natural materials; an imaginative and creative experimentalist; and the inventor and builder of numerous devices for laboratory instruction and research. Although he is probably most widely known for his consulting work on bauxite, dam sites, and mineral exploration, his most fundamental contributions to geology lay in the areas of the chemistry of mineral and rock changes and of the physical behavior of granular and solid materials under deforming stresses.

As the 20th century dawned, geology was full of problems in need of quantitative and experimental treatment. Descriptive and analytical data had been gathered in great amount during the preceding century and were being brought together in comprehensive works—annual reports, bulletins, monographs, professional papers, special reports, reference and text books, and so on—by federal and state bureaus and surveys, by college and university departments of geology, and by privately supported journals and publishers. Large accumulations of similar data were locked away in the confidential files of the great mineral exploration and mining companies. The time was ripe for young analytical minds, appropriately trained and oriented toward quantitative and experimental inquiry, to address themselves to some of these challenging problems. Such a mind was that of W. J. Mead, native son of northeastern Wisconsin, graduate of the University of Wisconsin (A.B., 1906; A.M., 1908; Ph.D., 1926) and longtime member of its faculty (1908–1934), and, after 1934, chairman of the Massachusetts Institute of Technology's department of geology, which he headed until his retirement in 1949.

Born in 1883 of a lawyer-politician father and a mother who loved gadgets and machines, and encouraged by a resourceful and imaginative high-school teacher of mathematics and science, the youthful Mead was deeply influenced by what was happening to his surroundings in a small country town north of Milwaukee as the 19th century was coming to an end. The Age of Electricity was beginning, and the old patterns of life were changing rapidly, with the introduction of electric lights, motors, bells, and trolleys. Little wonder that the imaginative youth from Plymouth registered for electrical engineering when he entered the university in the autumn of 1902. Soon, however, his interests turned to geology, and inspired by the teaching of N. M. Fenneman, he planned to do his senior thesis with that outstanding geomorphologist. This was not to be, however, for in his senior year he came under the influence of those two great Wisconsin geologists C. R. Van Hise and C. K. Leith, and thenceforth his geological career was shaped and guided by these two masters.

Skilled in observation, both by eye and with a camera; possessed of unusual ability to visualize lines, planes, and curved surfaces in three dimensions, thanks to superb training in geometry; master of the slide rule and possessing the engineer's knowledge of the mechanics of solids; of original bent and adept in the use of machine tools; and keenly interested in determining the how and why of natural phenomena and in developing ways and means of demonstrating and applying these phenomena, Warren Mead was exceptionally well equipped to attack both quantitatively and experimentally the whole broad front of physical geology as he entered Wisconsin's graduate school in 1906.



Warren J. Mead

Under the stern and demanding but nonetheless friendly guidance of Leith, then head of Wisconsin's department of geology, and with inspiring encouragement from Wisconsin's great geologist president, Charles R. Van Hise, Mead's abilities and energies were immediately put to the fullest test. From his fertile imagination and ingenious experimentation during the next two decades came an array of ideas, instruments, and devices that have had a profound effect on geology through the first half of this century. Not the least of Mead's contributions to geology were his lectures to geologists and civil engineers, numbered in the thousands, during more than four decades of teaching.

He taught structural geology for more than 45 years and to many hundreds of students, at Wisconsin (1908–34), the University of California at Berkeley (1926–27), and Massachusetts Institute of Technology (1934–49). In 1916 he organized one of the earliest courses in engineering geology for civil engineers and for the next 38 years taught the subject to many engineering students. His last formal lecture at Massachusetts Institute of Technology, delivered as honorary lecturer in June 1954, was to an enthusiastic class of civil engineers who warmly applauded him as he finished. To his teaching effort he brought carefully prepared lectures, memorable laboratory demonstrations made especially effective by his own original models and devices, and countless stories and episodes drawn from his widely varied academic and consulting experiences.

As a geological consultant and engineering geologist Mead gave advice and service on a wide variety of problems to many different clients, of which the following are some of the more important: Aluminum Company of America,

1912–50 (bauxite exploration and other problems); Panama Canal Commission, 1916 (earth slides); Colorado River Board, 1928 (Boulder dam); U.S. Army Corps of Engineers, 1932–37 (Garrison dam; Fort Peck dam; some 35 other dam sites); and Reynolds Metals Company, 1941–60 (bauxite and fluorspar exploration).

Whether as teacher, consultant, or administrator, Mead was quick to see how new principles, methods, techniques, and instruments could be applied to geological problems. When no device or instrument existed for some desired use, he frequently designed and made one. These inventions were quickly taken up and applied by others. His students will recall his novel method for making isometric block diagrams; his framed screen to illustrate the deformation of a circle; his clasp of thin flexible plates, unsupported at the two ends, to illustrate the ellipsoid of strain; his ingenious nomograph for graphically reducing great masses of physical measurements to simple cubic-feet-per-ton estimates of ore; his original three-dimensional model developed for his senior thesis to relate chemical data so as to establish the limits within which shale-sandstone-limestone ratios must fall; the circular slide rule he developed to accelerate the conversion of chemical data to mineral compositions; the numerous multicolored and multilayered sand and plaster of Paris models for illustrating folding and faulting; and last but certainly not least, the intriguing rubber bags, half-filled with sand, with which he successively demonstrated how the principle of dilatancy could be applied to the deformation of granular and solid materials (geology), the production of a soft molding device to help the prosthetics doctor, and the production of a soft but firm pillow for the radiotherapist. Regardless of the field of human problems or human endeavor into which his restless and inquiring mind wandered, he always found much of interest to challenge him. In his last years, with eyes dimmed after surgery, he still found the motivation and summoned the skill to design and make several ingenious devices for one of his sons to use in research on the physiology of respiration in Harvard's School of Public Health.

He was a member of the National Academy of Sciences, American Academy of Arts and Sciences, Geological Society of America (vice president in 1938), Society of Economic Geologists (president in 1942), American Institute of Mining and Metallurgical Engineers, and American Society of Civil Engineers. He is now remembered best by those he taught, but in the years to come it will be his original contributions in quantitative and experimental geology that will continue to be remembered and to have their influence on the science he served so well.

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Science in the News

Political Scientists and the Working Politician: Notes on the Campaign and the Take-Over

The Brookings Institution, a public affairs research institute, is working with representatives of the two presidential candidates on the problems surrounding the transfer of power to the new administration that will take office on 20 January. The project has a small staff of political scientists who are serving more or less as a secretariat for the project. Using past studies, conferences with men experienced at the top levels of government, particularly those familiar with the experience of the Truman-to-Eisenhower transition, and contacts with members of the present White House staff, the Brookings group is preparing a series of memoranda to be privately circulated among the staffs of the candidates.

It is too early to gauge the importance or the usefulness of the project, which will depend on how much influence the memoranda have on the thinking of the winning candidate. The project is indicative, in any case, of the growing interest of the politicians in the work of the academic political scientists. As government and the problems it must deal with have grown more complex, the mechanisms for making decisions have become more involved, and seeing that the decisions are carried out has become more and more difficult. The political scientist finds the politician interested in what can be learned from studies of past experience and analyses of what has worked well and what has led to trouble.

The transition period begins the day after the election and continues through the first months of the new administration. Neither candidate, of course, has dealt with any such problem before. Nixon has the advantage that he watched the Eisenhower take-over in 1952 from the inside and has close relations with a number of key Eisenhower appointees whom he would be glad to carry over into his own administration. Depending on how sharp a break he is anxious to make with the Eisenhower policies, it might be possible for him to move cautiously during the take-over.

Kennedy has no such choice. He is wholly committed to a sharp break with the Eisenhower policies, and it is necessary for him to move quickly to assert control of the bureaucracy. He must be ready to begin presenting specific proposals to Congress and the public immediately after his inauguration. When he made a speech a month ago talking of all the things he would do in the first 90 days if he is elected it sounded a little grandiose. But that was only a measure of the task he faces if he is elected, for everyone agrees that he will seriously, perhaps irretrievably, weaken his chances for making the major break with the Eisenhower policies he has in mind unless he succeeds in seizing the initiative and beginning to move very quickly immediately after his inauguration.

The role of the political scientist in this is to gather and analyze the experience of the past in the hope that it will offer the new President and his staff some useful insight about what

must be done to achieve effective control and to seize and maintain the initiative in putting a program across. A particularly successful example is Richard Neustadt's book, *Presidential Power*. It has attracted a great deal of attention in Washington and will almost certainly be read by and have some influence on the next President. For although the powers of the President are enormous compared with those of anyone else in the country, the powers are considerably less than enormous compared with the responsibilities the President must bear. Neustadt is concerned with what the President, one individual, can do to assert his influence on the government, the nation, and the world. And although both candidates are undoubtedly quite aware of the problem, neither has had the time, as the professional scholar does, to devote a major part of his working hours for several years to studying and thinking about the situation.

Brookings Study

The Brookings study is concerned only with the transfer of power. A particularly obvious problem relates to the budget. The Eisenhower budget that will be presented to Congress early in January will take no account of the new or expanded programs that both candidates have been talking about. It is being prepared under directives to keep spending down to the level of the current year, although Nixon estimates that his program would cost nearly $5 billion more than this year's, and Kennedy's program would run to considerably more than Nixon's. Either man must be prepared to offer a substantially revised budget very soon after inauguration day, which means that the man who wins must start working on a revised budget soon after election day. (Normally work on the budget begins a year before it is presented.) He must be prepared to appoint men to begin sitting in as "observers" in the key agencies and the Budget Bureau so that the new administration will be able to move quickly on 20 January, when it officially comes into power.

The Brookings memoranda will try to point up the key positions into which the President-elect should get a representative soon after the election. They will try to suggest the sort of relations that will exist between the incoming and outgoing administrations and to suggest approaches that might make the transition as painless as possible. They will outline some of the responsibilities that the new man must start to share immediately after election day; even without an international crisis between election day and inauguration, a good many decisions will have to be made by Eisenhower that will have repercussions beyond 20 January.

How much can the President-elect be expected to share in those decisions? How much influence, if any, can he try to exert on them? How much, if at all, can the new President's "observers" try to assert control over the agencies they are observing. The Brookings study, by drawing parallels with the experience of the Eisenhower take-over in 1952 will try not to provide answers but to provide background to help give the President-elect a firmer basis for making decisions on how to handle such problems. The usefulness of the Brookings work will depend on how much insight into the problems it can provide beyond what the candidate already knows from his own reading and from talking with people who went through the Eisenhower take-over.

Campaign Advice

Before the President-elect can start thinking about the take-over, he must become President-elect, and neither Kennedy nor Nixon has had much time in recent months to think about much other than the campaign. Here too the working politician is interested in what he can learn from the political scientists. He is particularly interested in what the scholars have learned about why people vote the way they do. He is also interested in what the offspring of the university scholar, the commercial poll-taker, can tell him about what is likely to win votes in this particular election. Staff members of both camps seem quite familiar with *The American Voter*, an elaborate study based on extended interviews published by the University of Michigan Survey Research Center. To the extent that it has had any substantial influence it would probably tend to lower the tone of the campaign, for the picture of the typical voter it presents is considerably less than the model of an enlightened citizen.

There has been pressure in Kennedy's camp, for example, based partly on studies such as the Michigan analysis, that the candidate ought to take up Harry Truman's cry and present himself as the spokesman for the little people and the opponent of the vested interests. The argument is that it is the bread and butter issues that the masses of the voters are really interested in, but Kennedy has stuck pretty much to his "let's get America moving" theme, and part of its effectiveness undoubtedly stems from the fact that he obviously believes in what he is saying.

As to the pollsters, it is probable that their influence is generally exaggerated. Only about 1 percent of the presidential campaign budgets are spent on polls, which suggests that the politicians do not value them so highly as to sacrifice many television appearances to save money to pay for more of them. For the most part they tend merely to confirm the politician's own intuitive feeling for what issues the voters are interested in. But although the issue polls are kept strictly private, it is reasonable to suppose that Kennedy had some encouragement from Lou Harris, the Democratic pollster, or at least not strong discouragement, when he decided to base his campaign on the issue of whether America was moving ahead in the world as it should. He has publicly stated that he is staking his campaign on the belief that the American people are uneasy about their position in the world and that he expects to lose the election if this is not true. To suggest that Harris's polls decided the course of the campaign would almost certainly be a great exaggeration. The polls may have been important, though, at least to the extent of giving Kennedy confidence that the issue he most wanted to talk about is an issue the public is in a mood to hear about.

On Nixon's side, Claude Robinson, the Republican pollster, probably had a parallel influence: subordinate, but not insignificant. Nixon talks of moving ahead as much as he can while still upholding, as he must, the Eisenhower record. "A record, no matter how good, is something to build on, not to stand on," he keeps saying. He struck this theme in his acceptance speech, so it is not merely a defensive attitude he was forced into during the course of the campaign. On the other hand, to be simultaneously upholding the record of the past and yet talking of the urgent need to do more blurs his image, as the phrase goes, and it is doubtful if he would have taken this somewhat awkward stand unless he believed the country just isn't in the mood for a stand-pat President; Robinson's polls very likely helped him reach that conclusion.—H.M.

News Notes

Committees of Scholars Support Candidates: Scientists Joining

The two presidential aspirants, Senator John F. Kennedy (D-Mass.) and Vice President Richard M. Nixon (R-Calif.), are being aided in their campaigns by volunteer committees of scholars that include a number of well-known scientists.

A National Committee of Arts, Letters and Sciences has been organized to provide support for Senator Kennedy. The membership consists of more than 250 well-known figures in American art, music, architecture, education, literature, and the social and natural sciences. Included are five Nobel laureates and 19 Pulitzer Prize winners. The committee, which has headquarters in Boston, was organized by John L. Saltonstall, Jr., Massachusetts lawyer and long-time political associate of Senator Kennedy.

Among the scientist members of the committee are the following Nobel prize winners: Arthur Kornberg, Polykarp Kusch, Fritz Lipmann, Edward M. Purcell, and Selman A. Waksman.

The list of the other scientists who have joined—the committee is still in the process of being formed—includes: Samuel K. Allison, Marston Bates, Hans A. Bethe, Harrison S. Brown, Martin Deutsch, Paul M. Doty, William A. Fowler, David Frisch, George A. Gamow, Trevor Gardner, Bentley Glass, Arthur Kantrowitz, Charles C. Lauritsen, Donald H. Menzel, John C. Sheehan, Kenneth V. Thimann, Stanislaw M. Ulam, Harold C. Urey, George Wald, Jerome B. Wiesner, Robert Woodward, and Jerrold R. Zacharias.

Republican Group Formed Earlier

The Republican committee, Scholars for Nixon-Lodge, was formed at a mid-August meeting in Washington of academic people called together by Professor Lon L. Fuller of Harvard University, committee chairman. The scientists in the organizational group were L. M. N. Bach, Gordon S. Brown, Edwin Crabtree, Robert A. Ellis, Raymond M. Fuoss, H. Tracy Hall, August de Belmont Hollingshead, Joseph Kaplan, Donald R. Korts, James C. Miller, Robert S. Mulliken, Milo J. Peterson, Wendell M. Stanley, Raymond W. Waggoner, and Robert A. Winters.

Last month the committee became a part of the arts and sciences division of the Republican National Committee in Washington. Three weeks ago 110,000 faculty members in universities all over the country were sent invitations to join the Nixon campaign. So far 1200 have responded, including a number of scientists. Among these are C. Raymond Adams, Garrett Birkhoff, P. Debye, F. L. Fitzpatrick, Helgi Johnson, Victor K. La Mer, Robert R. McMath, and David A. Wood.

Water Pollution and Public Health Topic of Special Federal Meeting

The need for more sewage and waste-treatment plants to control the increasing volume of pollution in the nation's rivers and streams will be a principal concern of the National Conference on Water Pollution, to be held 12–14 December in Washington, D.C. More than 1000 representatives of government, industry, and civic groups will participate in the conference, which has been called by Surgeon General Leroy E. Burney of the Public Health Service at the request of President Eisenhower and Arthur S. Flemming, Secretary of Health, Education, and Welfare. This is the first federally sponsored meeting to consider water pollution in relation to public health and to the present and future water needs of the national economy.

The agenda will include four day-long panel sessions which will cover (i) the impact of water pollution on public health and economic development; (ii) water resource management; (iii) the legal, financial, and public responsibilities of government and industry; and (iv) research and training needs. Recommendations from each panel will be discussed in a final general session. At a banquet on 12 December, national water pollution problems will be outlined in a round-table discussion by Senators Robert S. Kerr (D-Okla.) and Francis Case (R-S.D.), and Representatives John A. Blatnik (D-Minn.) and William C. Cramer (R-Fla.)

In calling the conference, Burney said that the nation is headed for a water crisis in the current decade unless a better job can be done to clean up the country's water resources. He commented:

"Since the start of World War II, construction of water supply and pollution control facilities has lagged far behind national needs. These needs will continue to grow during the 1960's as the result of population increases, the further concentration of people in metropolitan centers, and sharp increases in the use of water by households, farms, and industry."

The Public Health Service estimates that the construction of 4000 new sewage-treatment plants and the modernization of 1700 more is needed to handle the municipal sewage now dumped into rivers and streams. The service further estimates that it will take $4.6 billion worth of construction if municipalities are to catch up with treatment needs by 1968. This needed construction includes $1.9 billion to eliminate the present backlog, $1.8 billion to provide new facilities for population growth, and $900 million to replace obsolete plants.

Requirements for treatment facilities for industrial waste are more difficult to project than requirements of municipalities. However, the Public Health Service estimates that right now more than 6000 new projects are required for handling waste discharges. If built in today's construction market, these treatment facilities would cost about $2 billion, including in-plant changes. To wipe out the backlog of needed construction and to provide for growth, industry will have to spend between $575 million and $600 million annually if it is to catch up with needs by 1968.

For the past 4 years the federal government has been assisting localities in their efforts to control water pollution. Under Public Law 660, passed in 1956, the Public Health Service has provided $194 million in financial aid to communities for the construction of municipal sewage-treatment facilities. To this sum, cities and towns have added $925 million of their own, or about five times as much.

New Series of Oceanic Atlases

A new series of oceanic atlases was launched a month ago by the Woods Hole Oceanographic Institution with the publication of *The Atlantic Ocean Atlas of Temperature and Salinity*. The atlas was prepared by Frederick C. Fuglister and his associates as part of the institution's contribution to the International Geophysical Year. It represents many months of labor—making measurements at sea, compiling the data, and carefully preparing the final charts.

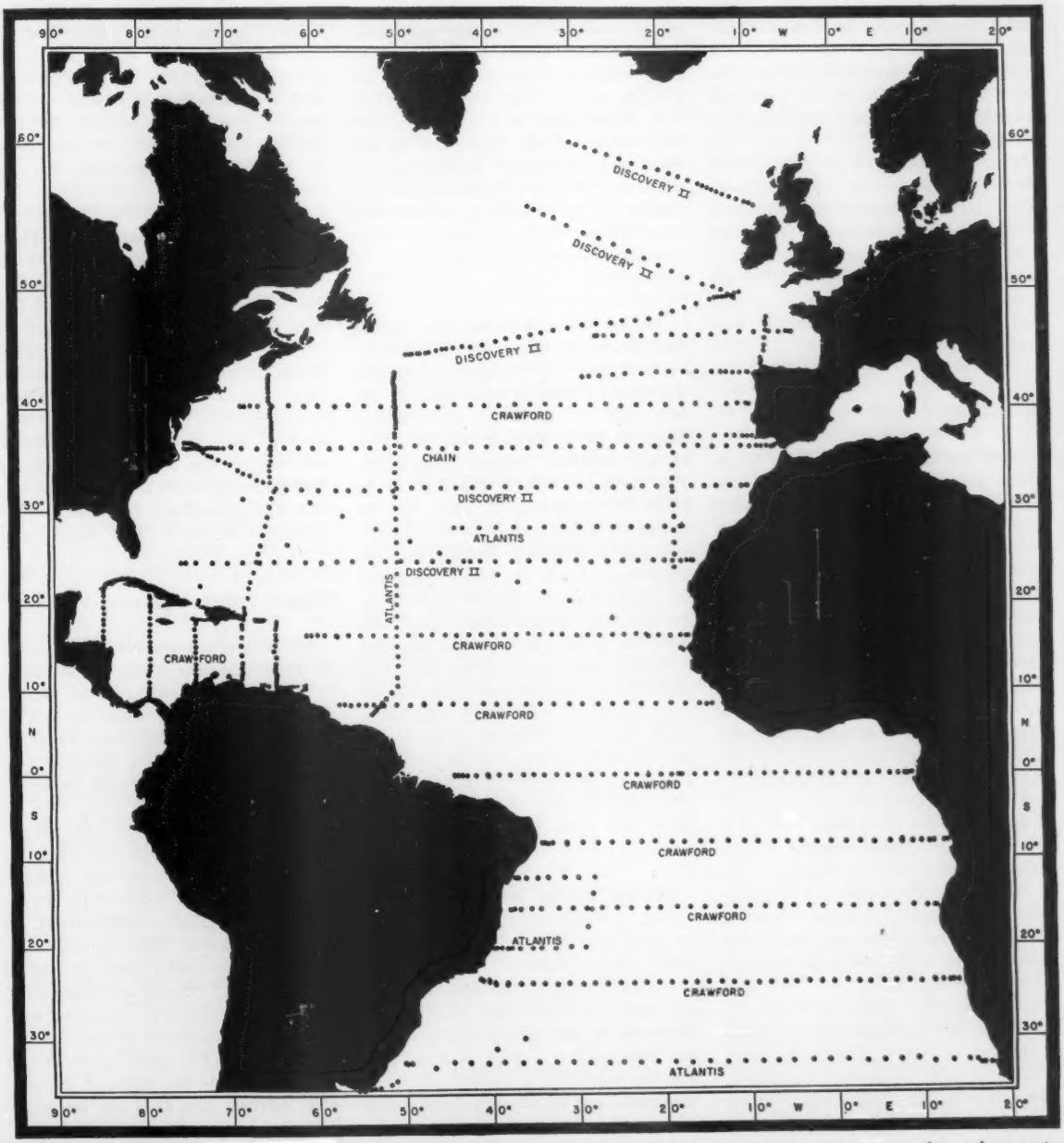
The core of the book is a section of 46 large colored charts, or profiles,

which show the salinity and temperature of the North and South Atlantic oceans from the surface to the bottom. Eight other profiles in color, the first of their kind to be published, give more detailed temperature information for the top 500 feet of water all the way across the ocean at different latitudes. In addition, all the data from which the profiles were drawn are included in the 210-page volume.

Printed on paper which was especially made for durability at sea, the publication is designed as both a reference book and a working tool for oceanographers, fishery scientists, submarine warfare specialists, and other students of the sea. Temperature and salinity information is basic to oceanic research for calculating water density and the distribution and movement of large masses of water.

The new atlas is the most complete collection of such data since the publication of the results of the expedition of the German ship *Meteor*, 1925–27; however, the *Meteor* concentrated on the South Atlantic and the Woods Hole work covers both the North and the South Atlantic.

The observations for the atlas were taken between September 1954 and July 1959 by scientists aboard the research vessels *Crawford*, *Atlantis*, and *Chain* of the Woods Hole Oceanographic Institution and *Discovery II* of the Na-



The area covered by the Woods Hole Oceanographic Institution's *Atlantic Ocean Atlas*. The dots represent stations where water samples were obtained.

tional Institute of Oceanography in England. In a methodical survey these vessels made 11 transatlantic passages between 32°S and 48°N and 12 shorter cruises in the North Atlantic and the Caribbean Sea. Some of the profiles, purposely made along the track of the *Meteor*, show a distribution of temperature and salinity in the deep water virtually identical with that of 30 years ago, indicating a basic stability of deep oceanic structure.

The chief scientists for the data-gathering cruises were Fuglister, L. Valentine Worthington, William G. Metcalf, and Arthur R. Miller, all physical oceanographers at Woods Hole. The work was supported by the National Science Foundation and the Office of Naval Research.

The first edition of the atlas (3000 copies) was financed by NSF in support of its IGY Interdisciplinary Research Program. Copies may be purchased from the Woods Hole Oceanographic Institution. Work is now in progress on a second volume, which will present data from world-wide study of the deep ocean.

News Briefs

South African radiotelescope. South Africa and the United States will cooperate in construction of a giant radiotelescope in a valley 20 miles west of Pretoria. The research center, to be designed primarily to follow space vehicles, is being sponsored by the U.S. National Aeronautics and Space Administration, which will provide a nucleus of trained personnel that will be gradually replaced by South African scientists and technicians. When it is completed, early next year, the telescope will have a main antenna 110 feet high and weighing 300 tons.

* * *

American Men of Science. The F–K volume of the 10th edition of the Physical and Biological Sciences series of *American Men of Sciences* was published in September. It is the second in the series, for which two remaining volumes will be released at approximately 8-month intervals. The four volumes together will contain the biographies of approximately 100,000 scientists.

Some 70,000 of these biographies were used to formulate the following percentage breakdown by field (the percentages total more than 100 because scientists in overlapping fields are listed in both): agriculture, 2.9 percent; animal husbandry, 1.3; astronomy, 0.5; biochemistry, 6.4; botany, 4.0; chemical engineering, 4.4; chemistry, 35.5; engineering, 13.9; forestry, 1.0; genetics, 1.0; geology, 4.1; mathematics, 4.9; medicine, 9.8; metallurgy, 1.4; nucleonics, 1.5; pathology, 2.9; pharmacology, 1.8; physics, 10.3; physiology, 2.2; public health, 0.9; surgery, 1.2; and zoology, 5.7.

* * *

Fishery nutrition. The United States Government will serve as host to a world conference on the nutritional value of fishery products during the last two weeks in September of 1961, according to an announcement by the U.S. Department of the Interior. The conference will be sponsored by the Food and Agriculture Organization of the United Nations. Approximately 400 authorities on nutrition, representing some 80 nations, are expected to attend the meeting, which will be held in Washington.

* * *

Animal behavior center. An unusual field station, the University of California Field Station for Research in Animal Behavior, is soon to be erected in the hills east of Berkeley. Construction funds of $367,700 have been provided by the National Science Foundation. The station, which is expected to be ready for occupancy in 1962, will be staffed by professors from the departments of psychology, zoology, and anthropology. Frank A. Beach, professor of psychology, is largely responsible for planning the new center, which will have ten or so structures and facilities, including tanks intended for fish, amphibians, or reptiles but drainable for use by small animals; bird observation cages expressly designed for photography, tape recording, and observation; a mammal enclosure, of about an acre, for group studies of dogs, sheep, or goats; and a monkey facility with observation platforms.

* * *

Cellular biology institute. The University of Connecticut has established an Institute of Cellular Biology to integrate and coordinate research and graduate training in the field. The new unit draws its membership from the departments of bacteriology, botany, animal genetics, and zoology. The institute will be guided by a faculty executive committee and an advisory council that includes the university's graduate deans and the following scientists from other institutions: J. Walter Wilson, professor emeritus, Brown University; Keith R. Porter, Rockefeller Institute for Medical Research; and Arthur Chovnick, director, Long Island Biological Laboratory.

* * *

Ford aids engineering. A series of grants to strengthen and expand engineering education at the doctoral level in Southern universities was announced on 27 October by the Ford Foundation. The awards, which amount to $3,110,000, will go to the University of Florida, Georgia Institute of Technology, North Carolina State College, and the University of Texas. These new grants bring to $29,235,000 the total of foundation assistance in the field of engineering education at colleges and universities since the first large-scale series of grants for this purpose was announced a year ago.

* * *

Council on the Aging. The National Council on the Aging, a nonprofit national organization, is being established and will be formally launched on 1 January. The organization grew out of the National Committee on the Aging, which since 1950 has been a standing committee of the National Social Welfare Assembly (345 E. 46 St., New York 17, N.Y.). The committee, which will become the council, has received appropriations from the Ford Foundation. The council will be an affiliate organization of the Welfare Assembly.

Grants, Fellowships, and Awards

NATO institute support. Short courses in which scientific topics are discussed at an advanced level may be eligible for financial support under the NATO Advanced Study Institutes Program. Courses should last for 2 weeks or longer, and participants should be drawn from several countries.

A NATO grant may be used for administrative expenses, for publication of proceedings, and to cover the expenses of foreign visitors. Courses in any of the sciences, including mathematics, are eligible for support. Meetings may consist of experimental classes, as well as the more usual lectures and discussions.

Persons interested in organizing such courses, and requiring financial assistance from NATO, should write *before 15 December* to the Office of the Science Adviser, NATO, Place du Maréchal de Lattre de Tassigny, Paris 16°, France.

Nutrition. Ten medical student fel-

lowships for research in clinical nutrition will be awarded in 1961 by the Nutrition Foundation, Inc., in honor of Richard W. Vilter, 1960 winner of the Joseph Goldberger Award in Clinical Nutrition. The fellowships, worth $200 a month for 3 months, will go to students who are recommended by senior investigators. Recipients will be selected by the Council on Foods and Nutrition of the American Medical Association. Applications should be made in writing by the senior investigator to the Council, AMA, 535 N. Dearborn St., Chicago 10, Ill., on or before *15 December*.

Radiological research. The James Picker Foundation has announced its program of awards in radiological research and nuclear medicine for 1961–62. The program is administered by the Division of Medical Sciences of the National Academy of Sciences–National Research Council. Applications for grants, scholar grants, and fellowships must be sent on or before *1 December* to the division's Committee on Radiology (NAS–NRC, 2101 Constitution Ave., NW, Washington 25, D.C.), which will provide detailed information on request.

The National Research Council of Canada serves as scientific adviser to the foundation with respect to its Canadian program. Inquiries and applications for support of studies to be carried out in Canada should therefore be directed to the Awards Office, National Research Council of Canada, Ottawa 2.

The Picker Program is divided into several categories.

Advanced fellowships in academic radiology. This new series of awards is open to the doctor of medicine who wishes to prepare himself for a faculty post in a medical-school department of radiology. While there are no rigid age limitations, candidates under 34 years of age will receive preference. Stipends will be determined on an individual basis.

Research fellowships. These fellowships are designed to provide an opportunity for young medical scientists who are not yet professionally established to gain insight into scientific investigation and to develop competence in its techniques and methods. Most of these awards will go to candidates who are not more than 30 years of age. The basic annual stipend is $4500. An additional allowance of $500 is made for a married recipient, plus an increment of $500 per child, to a maximum of $6000 annually. Travel expenses will be paid at the rate of 7 cents per mile, within the fellow's home country, from the location at the time of application to the institution of study. Should overseas travel be involved, a special allowance will be granted.

Grants for scholars. Grants for scholars in radiological research are a transitional form of support, designed to bridge the gap between the completion of the conventional type of postdoctoral research fellowship and the time when the young scientist has thoroughly demonstrated his competence as an independent investigator and is able to command research grant support. These grants are made to institutions for the support of specific individuals or their research, or both, during this critical initial period of their careers. The selection of the candidate is wholly the responsibility of the institution making the nomination. A grant of $6000 will be made directly to the institution to pay the salary of the scholar, or to defray the expenses of his research, or both.

Grants in aid of research. In this category, any project offering promise of improvement in radiological methods of diagnosis or treatment of disease is eligible for assistance. In line with the interests of the foundation, the program is oriented toward, but not necessarily limited to, the diagnostic aspects of radiology. In general, preference will be given to projects upon which some pilot studies have been made.

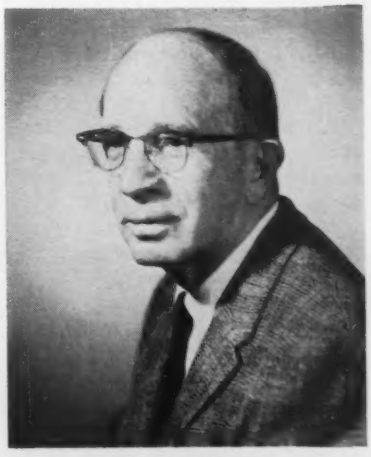
Social sciences. The Religious Education Association, a national organization, has recently received a substantial grant from the Lilly Endowment for the purpose of holding a Research-planning Workshop at Cornell University, 18–29 August 1961, in which approximately 25 social scientists and 25 religious educators will be invited to participate. The grant makes it possible for the workshop to pay travel expenses and the cost of room and board for all who attend. Stuart W. Cook, head of the psychology department at New York University, will be director of the workshop.

The workshop will be of interest to persons concerned with research on ethical values and religious ideas and practices of various populations. Those attending may explore the relation of such values to behavior. They may also explore the role of family, school, and church and synagogue and the impact of different cultures on religious thinking and character development. Underlying questions of personality theory and problems of communicating values and religious ideas will come within the scope of the workshop.

Further information may be obtained from the Research-planning Workshop of the Religious Education Association, P.O. Box 84, Cooper Station, New York 3, N.Y. Since *1 December* has been set as the deadline for applicants to furnish final data concerning themselves and their interests, persons wishing to attend the workshop are asked to write immediately. A limited number of scholarships to cover costs other than those of room, board, and travel, are available to applicants who would find it a hardship to meet such costs themselves. The Religious Education Association will assist workshop participants in finding sponsors or other means of support for research plans developed at the workshop.

Scientists in the News

I. Forest Huddleson, professor of microbiology and public health at Michigan State University, will receive the $1000 Kimble Methodology Award in San Francisco on 31 October during the Conference of State and Provincial Public Health Laboratory Directors. Huddleson developed the first satisfactory method for distinguishing the genus of bacteria known as *Brucella* in 1928. This bacteria is responsible for brucellosis (undulant fever) in human beings and Bang's disease in livestock. Recently he devised a simpler and more useful method for determining the presence of *Brucella* and other pathogenic bacteria in blood.



I. Forest Huddleson

Wallace O. Fenn, professor of physiology at the University of Rochester School of Medicine and Dentistry, will go to Paris on 4 November to receive an honorary degree from the University of Paris Faculty of Medicine. He retired as chairman of the physiology department a year ago but continues as professor.

Fenn, who has probably trained more outstanding physiologists than any other man of his time, has been a member of the Medical School faculty since 1924. He was one of the group of men that George H. Whipple, now dean emeritus, gathered around him to start the fledgling school. His scientific contributions may roughly be divided into three major areas: muscle mechanics and metabolism, electrolyte physiology, and the chemistry and mechanics of pulmonary ventilation. His recent research activities have been concentrated in the field of pulmonary gas exchange.

Miles D. McCarthy, formerly professor and chairman of the zoology department at Pomona College, is professor of biology and chairman of the division of science and mathematics at the newly established Orange County State College in Fullerton, Calif.

Other science appointments at the college, which has started its first full year, include:

Raymond V. Adams, formerly professor of physics and acting chairman of the physics department at Wayne State University, professor of physics and chairman of that department.

Dennis B. Ames, formerly professor and chairman of the department of mathematics at the University of New Hampshire, professor and chairman of the mathematics department.

Bayard H. Brattstrom, formerly of Adelphi College, assistant professor of zoology.

L. Clark Lay, formerly professor and chairman of the mathematics department at Pasadena City College, professor of mathematics.

James A. McCleary, formerly professor of botany at Arizona State University, professor of botany.

Donald D. Sutton, formerly research fellow at the Waksman Institute, associate professor of microbiology.

George C. Turner, formerly with the Claremont School District and the Claremont Graduate School, assistant professor of zoology in charge of science education.

Rudolf Florin, Bergius professor at the Royal Swedish Academy of Sciences in Stockholm and internationally known paleobotanist and expert on the living and extinct conifers, is serving as Hitchcock professor at the University of California. In five public lectures at Berkeley he is discussing aspects of the general theme "Conifer Distribution in Time and Space." The first lecture was delivered on 17 October; others will be heard on 1, 8, 15, and 21 November.

Harry E. Stockman, formerly professor and chairman of the department of electrical engineering at Merrimack College, has joined Lowell Technological Institute as professor in the division of physics and engineering science.

Paul J. Flory has resigned as executive director of research and as a trustee of the Mellon Institute, Pittsburgh; he will remain at the institute to devote full time to research in the field of polymer science.

Aurel O. Foster has been named director of the U.S. Department of Agriculture's Parasitological Research Laboratories at Beltsville, Md. In announcing the appointment to this new post, Byron T. Shaw, administrator of USDA's Agricultural Research Service, emphasized that the Service's parasite research programs at Beltsville will be equal in importance to the programs on domestic animal disease research at Ames, Iowa, and foreign animal disease research at Plum Island, N.Y. Foster has been in charge of ARS research on controlling animal parasites since 1941.

George R. Jenkins, associate professor of geology at Lehigh University and a member of the faculty for the past 12 years, has been named director of the Lehigh University Institute of Research. The institute, which administers a million-dollar program annually, was founded in 1924 to encourage and promote scientific research and scholarly achievement in every division of learning represented by the university.

The University of Maryland has appointed **Richard D. Richards**, for the past 2 years assistant professor of ophthalmology at the State University of Iowa, professor of ophthalmology and head of the department in the School of Medicine, in Baltimore. Richards is the university's first full-time professor of ophthalmology.

Recent Deaths

Grant I. Butterbaugh, Seattle, Wash.; 66; internationally known professor of statistics at the University of Washington; editor for 7 years of the *International Journal of Abstracts on Statistical Methods in Industry*; 21 Sept.

Pauline H. Dederer, New London, Conn.; 81; professor emeritus and former chairman of the department of zoology at Connecticut College in New London, 20 Aug.

George F. J. Kelly, Philadelphia, Pa.; 66; associate professor of ophthalmology at the University of Pennsylvania and senior consultant in ophthalmology at Children's Hospital; 6 Oct.

Frederick C. Lincoln, Washington, D.C.; 68; ornithologist and assistant to the director of the Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service; curator of ornithology at the Museum of Natural History in Colorado, 1913–19, and a federal employee since 1920; organized and directed the first government-sponsored bird-banding project in America; 16 Sept.

Benjamin Lipshultz, Philadelphia, Pa.; 72; assistant professor of neuroanatomy at Jefferson Medical College and former consultant in surgery at Einstein Medical Center; 9 Oct.

Herbert F. Schwarz, New York, N.Y.; entomologist associated with the department of entomology of the American Museum of Natural History for approximately 40 years; specialized in stingless bees; 1 Oct.

Alexander Skochinsky, Moscow, U.S.S.R.; 86; Soviet academician and scientist, who specialized in mining safety; conducted research on pit thermodynamics, the problems of gas and dust in coal mines, pit fires, and silicosis among miners; 6 Oct.

Paul K. Smith, Washington, D.C.; 52; professor of pharmacology and executive officer of the department of pharmacology at George Washington University's School of Medicine; pioneer in the search for drugs effective against poliomyelitis; conducted graduate work at Westminster College and at Yale University, where he also taught; 6 Oct.

Morris F. Weinrich, Irvington, Va.; 78; retired in 1952 as chairman of the Brooklyn College department of physics; specialist in various aspects of astronomy and meteorology, including artificial rain-making; taught at Columbia University and at Stevens Institute of Technology; 12 Oct.

Book Reviews

Indian Life in the Upper Great Lakes. 11,000 B.C. to A.D. 1800. George Irving Quimby. University of Chicago Press, Chicago, Ill., 1960. xv + 182 pp. Illus. $5.95.

For almost 13 millennia the Indians of the Upper Great Lakes region lived in adjustment to their natural environment and to each other. This adjustment was dynamic: glaciers scoured the continent, forests were ground away, lake basins filled and drained, and the great Pleistocene animals roved across the scene and became extinct. All the while man kept pace with events. Shifting residence in response to climatic change, he took up new weapons for new game and invented and learned to use different tools. Although he fought with his neighbors, sufficient numbers survived the battles to fight again. Outside tribes invaded the region, and their customs were borrowed, adapted, or rejected. In turn, the newcomers did the same.

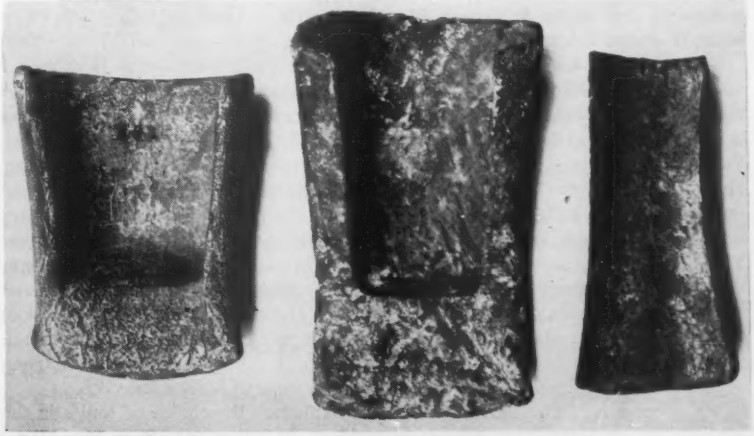
The story is alive with the resilience of man's struggle. Perhaps it was that changes whose cumulative effect was drastic, such as the retreat of the ice and the disappearance of the big game animals, were slow, and there was the opportunity to adjust. Or perhaps it was that when situations, such as tribe-to-tribe contacts, made for more rapid change, these changes were ameliorated by basic cultural similarities, and neither side was mortally hurt. But beginning about A.D. 1600 the Great Lakes Indian began to feel the impact of the European. By 1760 his capacity for adjustments to the innovations and pressures of this other world was nearing a breaking point. By 1820 it had snapped. His old way of life was no longer a coherent whole but a scattering of broken remnants on the white man's westward-moving frontier. Thus, in a little more than two centuries, changes had been wrought on the biological-cultural continuum of Indian existence which were more profound than any that had taken place in this region in the previous 13,000 years.

Quimby's book tells this history of an environment, peoples, and continuity of cultural traditions with clarity and directness. His work has the fine, and deceptive, simplicity of the mastered subject well-loved by its author. The book is addressed to the interested layman and the beginning student; however, in taking, and maintaining, this position Quimby has also produced an excellent synthesis for any reader. American archeology lacks good regional monographs. This is one.

The book is impressive in its interweaving of geological and archeological findings and in the explication of cultural-natural environmental relationships. The region is defined as the drainage basins of Lakes Superior, Michigan, and Huron. This composes the state of Michigan, parts of the states of Wisconsin, Minnesota, Indiana, and Illinois, and much of the province of Ontario. The geological time span begins with the Port Huron glacial advance (11,000 to 10,000 B.C.), comes up through the Two Creeks interstadial (10,000 to 9000 B.C.), the Valders advance (9000 to 8500 B.C.) and the Valders retreat (8500 to 6000 B.C.), what Quimby calls the "Terminal Glacial" (6000 to 3000 B.C.), and through the Postglacial to present times.

In this framework the author dates fluted Clovis points of the region in the Two Creeks and Valders eras (10,000 to 7000 B.C.). This was the time of the mastodon, the great forest browsers of the East. Following this, lanceolate point forms similiar to the Plano group of the West are associated with fossil beaches and water planes of glacial and ancient postglacial lakes. Apparently the conjunction of "Plano" and "water-planes" was too much for Quimby to resist, for he applies the term "Aqua-Plano" to this manifestation, which is dated fom 7000 to 4500 B.C. Deer, elk, and caribou were the principal game of these Aqua-Plano hunters. The beginnings of the Archaic cultures also fall in this chronological interval, but Boreal Archaic has its best expressions later, in the period from 5000 to 500 B.C. The Boreal Archaic adjustment is expressed in the fine polished stone tools used on wood: axes, adzes, and gouges. Pine and hardwoods were worked with these implements in making houses, canoes, and utensils.

Contemporaneous with Boreal Archaic is the distinctive Old Copper Culture (5000 to 1500 B.C.), one of the most unique of aboriginal North American developments, and related to, and perhaps a specialization out of, the Boreal Archaic. People of the Old Copper culture extracted copper from around the shores of Lake Superior by pit mining. By cold-hammering and by annealing (heating and hammering)



Socketed axes and gouge of copper from the Old Copper culture.

they fashioned some amazingly sophisticated socketed spear points, pikes, knives, and harpoons as well as axes, adzes, chisels, awls, needles, and drills. The gamut of tools implies a woodworking tradition similar to that of the Archaic people. Although not, technically, a true metallurgy, the copper industry of the Great Lakes region was the earliest use of metals in the New World, long antedating the metal industries in Peru and Bolivia. Unlike those areas, where gold was the first metal worked and ornaments were the first artifacts, the ancient Lake Superior Indians began with a utilitarian employment of copper.

Whether the idea of burial mounds originated locally or was diffused into eastern North America from the Old World, the earliest burial mounds of the Upper Great Lakes region appear to be derivative from the Ohio-Mississippi territory to the east and south. Pottery comes at about the same time (500 to 100 B.C.). Some of it is thick-walled, cord-marked or fabric-impressed, conoidal-bottomed ware, while another style is thinner walled and features dentate and rocker-dentate designs. Similar Woodland pottery seems to be earlier in the northeastern United States than it is in the Upper Great Lakes or elsewhere in North America; presumably it was diffused from east to west in the last half of the last millennium B.C. Hopewellian culture held the field in the Upper Great Lakes region from about 100 B.C. until A.D. 700. Sites of this affiliation are clearly restricted to the southern part of the region and are not found north of a line that marks a modern 150-day growing season. Agriculture was undoubtedly known from this time forward. Among the Hopewellian manifestations are big earthwork sites in the St. Joseph River valley and near Grand Rapids.

From A.D. 700 until 1600 a series of subregional archeological cultures are found which all adhere, more or less, to a similar pattern of life. Effigy Mound, Peninsular Woodland, Michigan Owasco, Lalonde, Fisher, Lake Winnebago, and Blue Island cultures are grouped into a general Late Woodland period. They show, in varying degrees, influences from contemporaneous Mississippian cultures to the south. They were the archeological cultures ancestral to the Great Lakes Indian tribes identified after A.D. 1600, including such groups as the Menomini, Chippewa, and Winnebago. In chapters that follow his archeological presentation, Quimby has written a series of descriptive essays about these tribes as they were recorded in the period from 1600 to 1760. In a final chapter he summarizes the breakdown of the native societies and cultures after 1760.

A summary, simplified statement of the kind that Quimby has made points up the major weaknesses in the prehistoric record. For example, archeologists do not know what happened in the late Paleo-Indian to Archaic transition. This is true for most of North America. Events of this time (7000 to 5000 B.C.) must have been related closely to important environmental changes, and since these changes were by no means the same in all parts of the Americas, we may hardly expect that all cultural reactions were the same. Surely, some Paleo-Indian groups must have adapted to the disappearance of Pleistocene fauna and conditions by taking up new ways of life. But to what extent these adaptions were sparked, abetted, or controlled by new immigrations and diffusions from Boreal Asia is, perhaps, the major question. A second puzzle is the source of Early Woodland pottery. Is it of Asiatic inspiration? Curiously, some of the closest correspondences are between northwestern Europe and northeastern North America. Finally, from whence came the elements that were drawn together and fused into the Hopewell florescence? And what was the role of maize agriculture in Hopewell? Quimby's geographical distributions of Hopewellian sites in the Upper Great Lakes region suggest a greater importance for agriculture than Caldwell has been willing to allow.

GORDON R. WILLEY

Peabody Museum,
Harvard University

Elements of the Theory of Markov Processes and Their Applications. A. T. Bharucha-Reid. McGraw-Hill, New York, 1960. xi + 468 pp. $11.50.

The staggering range of applications for Markov processes covers almost every subject from astronomy to zoology. Hence, the appearance of a book which brings together between its covers an introduction to most of these applications is indeed welcome.

Although the choice of topics in this book is fascinating, it is probably a necessary corollary that not all topics are treated equally well. Some, such as the discussion of stochastic models in biology, fare quite well; while others, such as applications in astronomy and chemistry, are discussed only superficially and seem to have been transported unchanged from the original papers to the book.

The book begins with an exposition of the theory of Markov processes in continuous time with a denumerable infinity of states, but discussion of finite state Markov processes in discrete time is omitted. A good deal of space is devoted to branching processes; here, as in many other parts of the book, the author quotes rather than proves many important results. There is an account of birth and death processes and results in the theory of random walks. A large portion of the theoretical section of the book is devoted to diffusion processes and the Fokker-Plank equation, including recent work by Darling and Siegert and by Feller.

The major part of this work is devoted to applications. In the section on biology, an obvious forte of the author, the list of topics includes birth and death models for population growth, the deterministic and stochastic theory of epidemics, the theory of genetic propagation, and areas of radiobiology. The chapter on the cascade theory of cosmic ray showers is of interest mathematically; of course it does not include more practical treatments of the problem. An account of the theory of Geiger counters as developed by Feller and Takacs is then given, and there are several miscellaneous topics in physics. The subjects in astronomy include work by Chandrasekhar and Munch on brightness fluctuations and by Neyman and Scott on the spatial distribution of galaxies. The final chapter, on queueing theory, includes accounts of all the principal formulations of the theory and several of the results.

The author is to be complimented on the unusual completeness of the bibliographies. However, there are an overly large number of typographical errors (for example, the startling interchange of Fig. 7.1 and Fig. 9.1). In summary, although no single subject can be learned completely from it, the book provides an excellent introduction to a wide scope of applications.

GEORGE WEISS

Institute for Fluid Dynamics and Applied Mathematics,
University of Maryland

Analytic Function Theory. vol. 1. Einar Hille. Ginn, Boston, Mass., 1960. xi + 308 pp. $6.50.

Americans are fortunate that a translation of Caratheodory's great *Theory of Functions* (Chelsea, 1954), which stresses the geometric aspects of function theory, has been followed so soon by an equally fine work in English, which stresses the analytic aspects of function theory. The first volume of Hille's treatise, here under review, is the best introduction to the classical theory which has yet appeared in our language. The book is well-planned, well-organized, and beautifully written. It will surely become a modern classic.

The prerequisite for reading this book is a good course in advanced calculus, which means that it could be used as a text in most American colleges for either senior students or first-year graduate students of mathematics. However, the book is much more than just another text. Hille, in addition, sets his subject in the broader framework of modern, functional analysis and topology. He also presents his subject as a living, evolving structure to which many minds have contributed. The interesting historical remarks and biographical details about the great mathematicians who have developed function theory give the book depth and spaciousness. They should also serve to help the aspiring young mathematician to

> Give past exemplars present room
> And their experience count as mine.

The mature mathematician will find the book excellent reading even when it deals with the most familiar subject matter. There is a continual succession of small novelties of proof and presentation. The style is concise but extremely lucid, and trivial details are not laboriously spelled out. However, I would like to see some mention of Menchoff's theorem in the chapter on holomorphic functions and a development somewhere of the Euler-Maclaurin sum formula. Without this, the deduction of Stirling's formula in chapter 8 seems a little heavy.

The plan of the book is sufficiently indicated by the chapter titles: Chapter 1, "Number systems"; Chapter 2, "The complex plane"; Chapter 3, "Fractions, powers, and roots"; Chapter 4, "Holomorphic functions"; Chapter 5, "Power series"; Chapter 6, "Some elementary functions"; Chapter 7, "Complex integration"; Chapter 8, "The calculus of residues"; Chapter 9, "Representation theorems."

There is a good selection of problems and of suggested collateral reading. The three appendixes on point set theory, properties of polygons, and the theory of integration make the book practically self-contained, and they enhance its value for self-study.

After such a fine beginning the mathematical world will look forward with interest to the projected second volume of Hille's treatise.

MORGAN WARD
Department of Mathematics, California Institute of Technology

Handbuch der Pflanzenanatomie. vol. 3, part 4, *The Plant Cell-Wall*. P. A. Roelofsen. Translated from the Dutch manuscript with the assistance of C. E. B. Bremekamp. Borntraeger, Berlin, 1959. vii + 336 pp.

The literature dealing with the chemical composition, physical properties, and microscopic structure of plant cell-walls, which has accumulated during a period of more than 100 years, is so voluminous that it is impossible to cover it in a single book. In this second edition, Roelofsen aims to give a critical exposition of the present state of knowledge with emphasis upon progress since the publication of the first edition (1925).

One cannot adequately evaluate the merits and significance of a book of such diversified subject matter in a review restricted to less than 500 words. In general, the book gives a critical and unbiased discussion of the limitations as well as the significance of techniques and of the reliability of generalizations that have been formulated by their use. It reveals how much still remains to be learned regarding diversified types of cell-walls. Thus, it provides a valuable reference book for chemists, physicists, and botanists who desire a résumé of available knowledge which provides clues regarding problems in need of future investigation and solution.

It should be noted in this connection, however, that there are rather conspicuous inequalities of treatment. In other words, there are parts of the text where the discussion is excessively brief and, at least in some of them, inaccurate or misleading.

For example, in dealing with the primary wall of growing cells, the orientation of cellulosic microfibrils in the lateral meristem or cambium is discussed. Unfortunately, the term *cambium* frequently has been expanded to include a relatively wide zone of soft tissue which includes not only the initials of the lateral meristem but also differentiating elements of the xylem and phloem. Therefore, in electron photographs obtained from disintegrated cells of the so-called cambial zone, there are no means of determining with certainty whether fragments were obtained from cambial initials or from their daughter cells in early stages of tissue differentiation.

In the case of the secondary wall, in contrast to the primary one, electron microscopy thus far has contributed little more than verification of conclusions reached during the 1930's by synthesis and harmonization of evidence obtained by "ordinary" microscopic techniques, polarization microscopy, and x-ray analyses. The literature of this significant transitional period certainly merits more adequate consideration.

There is a curious misinterpretation of my own work. Illustrations of the cross-section of a *Pandanus* fiber and of the phenomenon of "ballooning" in such a cell are reproduced with implication of an erroneous conclusion. A careful reading of our original paper and of a subsequent one which has diagrams illustrating changes in fibrillar orientation demonstrate that our interpretation of ballooning was correct.

I. W. BAILEY
Harvard University Herbarium, Harvard University

Marine Algae of the Eastern Tropical and Subtropical Coasts of the Americas. William Randolph Taylor. University of Michigan Press, Ann Arbor, 1960. xi + 870 pp. Illus. $19.50.

The appearance of this long-awaited work is an event of great importance. Until now, the marine algae of the vast western Atlantic warm-water shores of the Americas, from North Carolina to Uruguay, could be identified only by referring to a large number of scattered publications. Recent recognition of the role of marine resources in the Latin American economy

has underscored the need for a comprehensive descriptive list of seaweeds. Taylor has filled this need in a superior manner. His field and herbarium experience of more than 30 years, his skill in bookmaking, his ability to see the forest despite the trees—these qualifications are manifest throughout the book.

The descriptive catalog, which comprises most of the book, treats 760 species. Diagnoses are given for all taxa of the rank of order and below, while keys are provided for families, genera, and species. There are 80 plates of line drawings and photographs. The bibliography is exhaustive.

Taylor offers, in addition to the descriptive catalog, a historical survey, directions for collecting and preserving specimens, and a particularly informative discussion of the geographic and ecological distribution of seaweeds, illustrated by excellent photographs.

A reviewer of a taxonomic work need not look hard to find points of disagreement, but these differences of opinion do not necessarily detract from the utility of the work. It is disappointing, however, to encounter various new nomenclatural and taxonomic decisions for which no supporting arguments are given.

The jacket refers to this work as a manual, but it is even less a manual than it is a definitive floristic monograph. Actually, it is an elaborate study outline: a carefully compiled check list based on literature and herbarium records, augmented by field study in selected areas. Phycologists should be grateful for this foundation for future study and should not be too dissatisfied with the unevenness of treatment, both geographic and taxonomic, or with the large number of loose ends, which Taylor wisely chose to spotlight rather than to conceal.

PAUL C. SILVA

Department of Botany, University of Illinois

Under the Deep Oceans. Twentieth century voyages of discovery. T. F. Gaskell. Norton, New York, 1960. 240 pp. Illus. $3.95.

Many people who work on the oceans seem at some time to keep a personal log or journal. Gaskell's book *Under the Deep Oceans* will be particularly interesting to those who have tried to write down their experiences in quiet seas or strange ports. Anecdote and humorous comment on things done and places visited by the *Challenger* Expedition of 1950 are the media holding Gaskell's account together. The author's style resembles "sea-story" sessions often held on the fantail of ships.

The scientific text is a straightforward, much-condensed discussion of many aspects of marine science, with emphasis on the part played by the *Challenger* cruise in collecting data. The author takes every opportunity to point out the usefulness of marine science to society, particularly to the oil industry and the Royal Navy. Gaskell points to the similarity of interest between marine scientists and the oil industry in developing instruments—such as seismic apparatus—and in developing various drilling techniques, and he urges the oil industry to give additional support to deep-ocean research.

Readers will find this book entertaining; the author does not waste a good story because he happens to be involved in discussions of seismic records or the difficulties of fixing position at sea. Even while readers ponder the punishment for adultery at Nukufetau, it is apparent that the author has led them through a rather wide variety of basic problems associated with the seas.

JOHN M. ZEIGLER

Woods Hole Oceanographic Institution, Woods Hole, Massachusetts

New Books

General

Sax, Karl. *Standing Room Only.* The world's exploding population. Beacon Press, Boston, ed. 2, 1960. 206 pp. Paper, $1.75.

Schapero, Max, *et al. Dictionary of Visual Science.* Chilton, Philadelphia, Pa., 1960. 799 pp. $15. Contains over 13,000 listings; a total of 61 collaborators and contributors are listed. Examples of contents: "A case. See *case, type A.*" "macula (mak'ulah). Any uniquely pigmented area such as the macula lutea of the retina. 2. A corneal macula."

Mathematics, Physical Sciences, and Engineering

Brinkmann, Roland. *Geologic Evolution of Europe.* Translated by J. E. Sanders. Enke, Stuttgart; Hafner, New York, 1960. 161 pp. $8.50. A condensed version of the second volume of ed. 8 of *Abriss der Geologie.* Only those parts which refer to the geology of Europe were translated.

Coulson, Kinsell L., Jitendra V. Dave, and Zdenek Sekera. *Tables Related to Radiation Emerging from a Planetary Atmosphere with Rayleigh Scattering.* Univ. of California Press, Berkeley, 1960. 560 pp. $12.50.

Dunsheath, Percy. *Electricity.* How it works. Crowell, New York, 1960. $3.95.

Hohn, Franz E. *Applied Boolean Algebra.* An elementary introduction. Macmillan, New York, 1960. Paper, $2.50.

Hoyle, Fred. *The Nature of the Universe.* Harper, New York, rev. ed., 1960. 141 pp. $3.

Judkins, Henry F., and Harry A. Keener. *Milk Production and Processing.* Wiley, New York, 1960. 460 pp. $7.95.

Kleinberg, Jacob, William J. Argersinger, Jr., and Ernest Griswold. *Inorganic Chemistry.* Heath, Boston, 1960. 688 pp. $10.75.

Leet, L. Don. *Vibrations from Blasting Rock.* Harvard Univ. Press, Cambridge, Mass., 1960. 134 pp. $4.75.

Mach, Ernst. *The Science of Mechanics.* A critical and historical account of its development. Translated by Thomas J. McCormack. Open Court Publishing Co., LaSalle, Ill., ed. 6 (with revisions through ed. 9), 1960. 665 pp. $6.

Marton, L., Ed. *Advances in Electronic and Electron Physics.* vol. 12, *Photo-Electronic Image Devices.* J. D. McGee and W. L. Wilcock, Eds. Academic Press, New York, 1960. 409 pp. $12. This volume is the proceedings of a symposium convened in London by McGee during 1958.

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Reports

Distribution of Phage Groups of Staphylococcus aureus in the Years 1927 through 1947

Abstract. The phage typing patterns of 194 typable strains of *Staphylococcus aureus* isolated in the years 1927 through 1947 and preserved as stock cultures revealed that 43 strains were of phage type 80/81. The occurrence of other typable strains in the broad phage groups I, II, and III corresponded closely to the frequency distribution of staphylococci reported in 1945 by Wilson and Atkinson.

Strains of *Staphylococcus aureus* of phage type 80/81 have assumed a position of some prominence during the past few years, especially in relation to their role as causative agents of some hospital-acquired infections. It has been possible to identify these strains only since about 1955–56, when phage 80 was described by Rountree and Freeman (*1*), and phage 81 by Bynoe, Elder, and Comtois (*2*). For this reason it would almost appear that there has been a tendency to regard type 80/81 as a "new" staphylococcus which has just recently made its appearance. This is by no means the case, for Rountree (*3*) found that the Bundaberg strain of *S. aureus*, which was responsible for a series of fatalities in Australia in 1928, exhibits the phage pattern 52/52A/80/81, and the present report demonstrates that strains *S. aureus* of phage type 80/81 have been not uncommon during the past 33 years. Specifically, this report describes the examination of a series of strains that were isolated between August 1927 and December 1947.

In "phage type 80/81" are included, for the purpose of this report, all strains of coagulase-positive staphylococci that show the phage patterns 80/81 or 52/52A/80/81, or any combination of these phages, or that are lysed only by phage 80 or by phage 81. Recent reports by Asheshov and Rippon (*4*) and by Rountree (*3*) on the changes in phage typing patterns of staphylococci of type 80/81 after lysogenization suggest strongly that strains which exhibit patterns comprised of various combinations of these phages are so closely related as probably to represent an entity. Work now under way in our laboratory confirms their observations and inferences.

A total of 276 strains of coagulase-positive staphylococci was examined. Of these, 256 were isolated in our laboratory from pathologic material submitted for bacteriologic diagnosis between August 1927 and December 1947. The strains were isolated from 242 individuals; when more than one strain was available from a single individual, only those isolates which showed distinctly different phage patterns, and represented obviously different strains, were included in the tabulation. The series represents a random selection of cultures that were collected during the period mentioned; they were saved and placed in stock because of their varied clinical sources or because of their range of toxigenic and other properties. Twenty strains were received from other investigators during the same period.

Stock cultures were maintained on Difco brain-heart-infusion agar slants at room temperature. The culture tubes were sealed with sterile cork stoppers, and the stoppers and upper portion of the tubes were then coated with paraffin. Transfers were made at an average interval of about 1 year. Fresh transfers on agar were made when the cultures were about to be phage typed.

The phages used for typing were as follows: group I—phages 29, 52, 52A, 79, 80; group II—phages 3A, 3B, 3C, 55, 71; group III—phages 6, 7, 42E, 47, 53, 54, 73, 75, 77, 83; group IV—phage 42D; miscellaneous—phages 81, 187. The methods employed were those described by Blair and Carr (*5*) and conform to the recommendations of the International Committee on Phage Typing of Staphylococci. All cultures were typed first with the phages at their routine test dilutions. Those cultures which were not lysed or which showed only weak reactions at routine test dilutions were retyped with the phages in concentrations 1000 times stronger. The patterns were recorded in terms of those phages which produced significant reactions of from 50 plaques to confluent lysis. Cultures which showed no pattern of significant lysis either at routine test dilutions or at concentrations 1000 times stronger were recorded as nontypable.

This report is based upon the phage typing of all strains of the series during the spring of 1960. While a primary object of the study was to determine the presence of strains of type 80/81 in the collection, the opportunity also was provided of demonstrating the distribution of the other strains among the broad phage groups. It may be noted that several of the cultures had been typed on one or more occasions previously during the past 12 years. The basic stability of the phage patterns of staphylococci is indicated by the fact that patterns exhibited by such cultures in the earlier typings were confirmed during our examination.

In the series of 276 strains, 194 (70.3 percent) were typable and 82 (29.7 percent) were nontypable. The number of typable strains which showed phage patterns in the several broad groups or types was as follows: group I, 63 (32.5 percent); group II, 42 (21.6 percent); group III, 17 (8.8 percent); group IV, 9 (4.6 percent); "type 187," 5 (2.6 percent); "type 80/81," 43 (22.1 percent); and mixed (patterns overlapping two or more groups), 15 (7.7 percent).

Six phage patterns were found among the 43 strains of type 80/81. The several phage patterns (all considered to indicate the broad type 80/81) were as follows: 52/52A/80/81, 14 strains; 52/52A/80, 15 strains; 52A/80, seven strains; 52/80, one strain; 80/81, one strain; 80, two strains; and 81, three strains. The earliest of these strains, with the pattern 52/52A/80/81, was isolated in August 1927. The majority of the strains of type 80/81 were isolated from various clinical forms of staphylococcal disease, including acute and chronic osteomyelitis, soft-tissue abscesses, boils, carbuncles, and bacteremia; a few were isolated from miscellaneous other conditions such as cervical adenitis, cellulitis, conjunctivitis, and meningitis. In the light of current observations on infections due to type 80/81, it may be noted that two strains were responsible for postoperative infections and one for a breast abscess.

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

Forty-nine of the total number of strains in the series were isolated during the period 1944 to 1947—that is, during the early era of penicillin therapy. Seven of these strains were type 80/81, and of these, six were sensitive to penicillin as determined by the tube-dilution method. The one resistant strain had been isolated before the patient received penicillin, and the strain was inhibited by 6.25 units of the antibiotic. In one instance a penicillin-sensitive strain with the pattern 52/52A/80 was isolated from an osteomyelitic lesion before the start of antibiotic therapy; after the administration of penicillin for 1 month, a strain (not included in the tabulation) showing the same phage pattern was isolated from the same lesion and was found to be inhibited by 50 units of the antibiotic.

The only previous report with which our observations can reasonably be compared is that by Wilson and Atkinson (*6*) in 1945, in which are described the techniques of staphylococcal phage typing upon which current methods are based. The majority of the strains examined by Wilson and Atkinson were derived from a variety of infections during a part of the same period covered in our report. Although the typing schema of Wilson and Atkinson is rather different from that in current use, they did recognize certain broad categories which now correspond to groups I, II, and III. When their figures for the frequency distribution of "types" are rearranged to correspond to groups I, II, and III, it is found that the proportion of typable strains encountered in the three groups by Wilson and Atkinson and by us, respectively, are as follows: group I, 33.4 and 32.5 percent; group II, 19.4 and 21.6 percent; and group III, 9.4 and 8.8 percent. Type 80/81, as such, was not identified until 10 years after publication of the report of Wilson and Atkinson. Lysis in the pattern 52/52A was not mentioned specifically by Wilson and Atkinson, and it can be only a matter of conjecture whether any of the strains which they reported to be lysed by phage 52 or phage 52A actually represented type 80/81. It is of some interest, however, to note that five strains of type 80/81 in the present series had been submitted to phage typing 10 or 12 years ago and had been found to be lysed by phages 52 or 52A, or both.

The low incidence of group III strains reported by Wilson and Atkinson and encountered in this series is in striking contrast to the predominance of these strains that became apparent not long after the introduction of antibiotic therapy (*7*). A trend in this direction was seen in the present series, for group III strains, among the strains isolated from 1944 through 1947, were increasingly more numerous, and more frequently penicillin-resistant.

Although the incidence of strains in this series is reported in terms of percentage, we do not intend to imply that the figures necessarily indicate the true distribution of staphylococci among the broad groups during the 20 years in question. We feel, however, that the figures have some degree of validity, to the extent that they express the broad relationships of the several groups and correspond closely to the observations made by Wilson and Atkinson at a similar period of time. There is little question that type 80/81 was a not insignificant cause of staphylococcal disease long before its recent rise to prominence (*8*).

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1 August 1960

Nomenclature of Devices Which Simulate Biological Functions

Abstract: The suffix *-mime* is proposed to create generic names for the general class of man-made devices which simulate biological functions. The suffix is used after the stem of the word that describes the organ or cell being simulated; for instance, artificial neurons are described as neuromimes.

With increasing knowledge of the mechanisms of many biological functions, and concomitant development of technology, it has become possible in recent years to construct (or computer-simulate) devices of one sort or another which, to a specified extent, can act like and even replace parts or organs of the living organism. Such artifices as heart-lung systems, which allow prolonged surgery on the heart and pulmonary system, artificial kidneys, which take over renal function temporarily or even semipermanently, and most recently, artificial neurons, which are providing a valuable tool in neurophysiological research, are examples. In the near future many more developments in this direction may be anticipated.

In discussing these devices authors unavoidably make comparisons between the performance of their inventions and the "real thing," draw conclusions on the basis of experiments with their analogs which they wish to apply to the living structure, and attempt to correct their artifacts as a result of apparent discrepancies between artificial and biological behavior.

In all of such activity, juxtaposition of the same names referring to the device and to the "prototype" is likely to become confusing to the reader who may be at a complete loss in trying to find out whether the "neuron" the author is discussing is the real or the simulated thing. The author, anticipating this, can find several ways to avoid confusion.

One obvious way is to label his device, whenever he is talking about it, "artificial"; but this becomes clumsy, and after a few papers on the subject, authors tend to assume that by now everybody knows what they are writing about, and drop the adjective. Another method is to baptize the device with some arbitrary name, for example, ARKID for artificial kidney, or CARDIOTRON for an artificial heart-lung system; the -tron suffix seems to be especially popular. The trouble is, again, that the author (usually after the first paper) neglects to clarify the name, or at most refers to it in a footnote.

There seems to be reason, therefore, to make a case for universal nomenclature specifically designed for artificial devices which simulate to some extent biological functions. Such a nomenclature should meet several criteria: (i) It is desirable, for purposes of orientation, that the stem of the word which refers to the original cell or organ be retained; so, in artificial kidney systems the stem *nephr-* or *ren-* should occur, in heart-lung systems *card-* or *pulm-* should be present, and artificial neurons should have *neur-* or *nerv-* in their names; (ii) For convenience in writing and speaking, a single word of not more than three or four syllables should suffice. This leads immediately to the necessity of using prefixes or suffixes; (iii) The affix, then, should be easily recognized for meaning: -like, simulating, analog of, behaving as if, and so forth; (iv) Affixes already much in use, such as *para-*, *meta-*, *-oid* and *-id* should, where possible, be avoided, so as not to evade one confusion by creating another.

The choice now narrows down to a few relatively little-used affixes, of which the prefix *sim-* or *simu-* (from

the Latin stem: *simul-* = -like, as in *simulare* = simulate), and the suffix *-mime* (from Greek stem: $\mu\mu\eta$ = imitate, as in pantomime), appear best suited. Of these two, *sim-* (or *simu-*) is the more difficult to identify in formations such as: simuneuron, simunephron or simoculus (artificial eye).

I would, therefore, propose that the suffix *-mime* be adopted to designate artificial devices simulating biological functions. The suffix should be understood to mean that the device under discussion belongs to this general class of artifices. Thus, the *-mime* ending can be considered to yield a generic name, whereas authors are, of course, free to name their inventions by any specific name they please. So ARKID is a species of *nephromime*, cardiotron is a *cardiomime*, and the Perceptron (a mathematical model) is an *oculomime* or *neuromime*, depending on one's emphasis. The various types of transistorized artificial neurons are all neuromimes, and so are nets of computer-simulated models.

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15 June 1960

Acetylcholinesterase Regeneration in Peripheral Nerve after Irreversible Inactivation

Abstract. The return of acetylcholinesterase activity was studied in several cholinergic structures in the cat after irreversible inactivation by di*iso*propylfluorophosphate. It was found that enzymic activity returned uniformly along the hypoglossal and cervical sympathetic nerve trunks. No evidence for somatoaxonal convection of enzyme was obtained.

It is widely held that axonal protein is formed in the perikaryon of the neuron and conveyed peripherally by centrifugal displacement of neurocytoplasm or axoplasmatic currents. This conception developed first as a result of the comprehensive studies of Weiss and Hiscoe (*1*), which suggest the phenomenon of somatoaxonal convection of axoplasm. Secondly, when the essential role of ribonucleic acid in protein synthesis became appreciated, its absence from the axon in the form of visible aggregates of ribonucleoprotein (variously termed Nissl substance, granular endoplasmic reticulum, and ribosomes) lent further credence to the concept of dependence on the perikaryon for biosynthesis of prctein for the remainder of the neuron. However, it might be pointed out that the complete absence of ribonucleic acid from the normal, mature axon has never been proven, and that ribonucleic acid is certainly not absent from embryonic nerve (*2*).

The evidence that enzymes, specifically cholineacetylase and acetylcholinesterase, migrate distad in the axon after their formation in the cytoplasm has been suggestive, albeit somewhat tenuous. Thus, Hebb and Waites (*3*) and Sawyer (*4*) demonstrated an increase in enzymic activity of cholineacetylase and acetylcholinesterase, respectively, in the regenerating proximal stump of peripheral nerve after sectioning. In addition, Lewis and Hughes (*5*), using a nonspecific histochemical method, demonstrated that cholinesterase is present in the outgrowing embryonic nerve of the toad *Xenopus laevis*. However, a histochemical study by Schwarzacher (*6*) of acetylcholinesterase content in neuronal somata during peripheral nerve regeneration indicated that this enzyme is not present in the perikarya during the outgrowth period. The last-mentioned finding controverts the validity of the conclusion, generally drawn in previous studies by many workers in the field, of somatoaxonal migration of acetylcholinesterase. The observations of Sawyer (*4*) and Schwarzacher (*6*), considered together, suggest rather that the biosynthetic systems for acetylcholinesterase may migrate only during growth (that is, during regeneration and embryogenesis). If the dissolution of Nissl substance (chromotolysis) which invariably follows axonal sectioning is regarded as the mobilization of ribonucleic acid for its axonal passage, this phenomenon lends further support to the latter hypothesis.

The most direct evidence for axonal migration of protein was obtained by H. Koenig (*7*) and Waelsch (*8*), employing intrathecal administration of isotopically labeled amino acids in the cat and frog, respectively. "Peaks" of radioactivity in peripheral neuronal protein were observed by Koenig to be displaced peripherad in the ulnar and sciatic nerves at rates ranging from 2 to 11 mm/day.

Fukuda and Koelle (*9*), in a histochemical study, using the thiocholine method of Koelle (*10*), showed that the cytoplasmic acetylcholinesterase of the neurons of the cat ciliary ganglion has a distribution pattern closely resembling that of the Nissl substance. In addition, following inactivation by di*iso*propylfluorophosphate, the regenerating acetylcholinesterase appeared in the cytoplasm before its presence in the surrounding preganglionic axonal terminals could be detected. Such observations support the general contention of somatic synthesis of the enzyme prior to its transit to the periphery.

On the assumption that the "somatoaxonal convection hypothesis" is true for acetylcholinesterase, it should be possible to demonstrate a proximodistal "activity" gradient of the enzyme along the nerve after its irreversible inactivation. In order to test this hypothesis, a high dose (40 μmole/kg, given intravenously) of the irreversible anticholinesterase agent, di*iso*propylfluorophosphate, was administered to anesthetized cats previously treated with atropine (5 mg/kg), and the regeneration of acetylcholinesterase was followed over a period of 1 to 15 days in selected cholinergic structures. The enzyme activity was assayed by a modification of the method of Bonting and Featherstone (*11*), with methacholine as substrate. The following structures were studied: (i) hypoglossal nucleus; (ii) three successive segments of peripheral hypoglossal trunk; (iii) two successive segments of the distal portion of the cervical sympathetic trunk; (iv) superior cervical ganglion (acetylcholinesterase localized chiefly in cholinergic axonal terminals); (v) ciliary ganglion (acetylcholinesterase localized chiefly in neuronal cell bodies); and (vi) the inferior oblique muscle of the eye. The structures were selected to yield as complete a picture as possible of the regeneration of acetylcholinesterase in cholinergic somata, axons and axonal terminals, and a nonneuronal tissue.

Figure 1 shows the patterns of acetylcholinesterase regeneration observed in the structures studied. Of primary

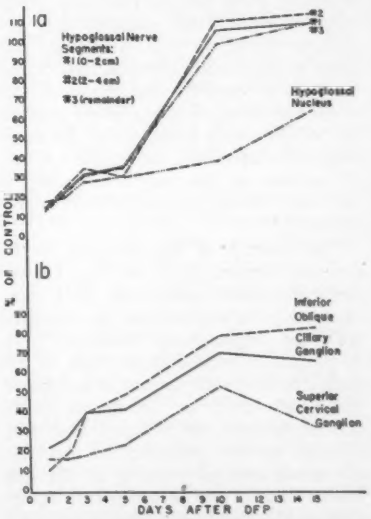

Fig. 1. Return of acetylcholinesterase in (*a*) the hypoglossal nucleus and nerve, and (*b*) the superior cervical and ciliary ganglia and inferior oblique muscle, after irreversible inactivation by di*iso*propylfluorophosphate. The time intervals of the study were 1, 2, 3, 5, 10, and 15 days. Each point represents the average for three animals with the exception of the point for the 2-day period, which represents the average for two animals.

significance is the uniform rate of regeneration of acetylcholinesterase along the entire length of peripheral hypoglossal nerve (Fig. 1*a*) at the time intervals of the study. A uniform rate of regeneration of the enzyme was found, also, for the cervical sympathetic trunk. However, unlike the finding for the hypoglossal nerve, the acetylcholinesterase of the cervical sympathetic trunk was regenerated only to approximately 45 percent by the 15th day. A possible explanation for this difference may lie in the fact that the cervical sympathetic trunk has approximately 15 times as much acetylcholinesterase activity per mg wet weight as the hypoglossal. Nonetheless, it is highly improbable that the regeneration of acetylcholinesterase is a result of spontaneous hydrolysis, since evidence indicates convincingly that once the ageing of the phosphorylated enzyme is complete (within 1 day), it is irreversibly inactivated (*12*). Even if the highest rate (11 mm/day) reported by H. Koenig (*7*) for axoplasmic flow in some fibers of the sciatic nerve is assumed to obtain in the hypoglossal nerve, axoplasmic flow is far too slow to account for the uniform return of enzyme along the trunk.

Additional evidence for the relatively independent nature of the peripheral return of the enzyme may be inferred from a comparison of the curves for the hypoglossal nerve and its nucleus (Fig. 1*a*). It can be seen that no gradient exists between the nucleus and peripheral nerve; in fact, a reverse gradient is in evidence between days 5 and 15. It is noteworthy that the total acetylcholinesterase contents of the nucleus and of the whole trunk are of the same order of magnitude; hence, the amount of enzyme in the peripheral nerve is not just a small fraction of the cellular enzyme.

The pattern of regeneration in the superior cervical ganglion (Fig. 1*b*) appears somewhat anomalous. Since most of the acetylcholinesterase is associated with the preganglionic terminals (*13*), its pattern of regeneration might be expected to be similar to that of peripheral nerve. However, no significant return was noted until the 5th day. This may account for the difference in the time of appearance of enzyme in the cell bodies and in the preganglionic terminals of the ciliary ganglion after di*iso*propylfluorophosphate inactivation (*9*) (see above). The reasons for these differences can be only a matter of conjecture at present. Furthermore, although the average enzymatic activity appears to decline between days 10 and 15, the decline is probably apparent rather than real, since the small number of experimental animals, coupled with wide variation in normal, control values for the superior cervical ganglion, probably accounts for the apparent reduction. The pattern of regeneration in the extraocular muscle (Fig. 1*b*), on the other hand, is similar to what other workers have reported (see Denz, *14*).

Experiments are now in progress in which an attempt is being made to dissociate the regeneration of acetylcholinesterase in the peripheral nerve trunk from that in the nucleus by chronic suppression of the build-up of enzyme at the latter site with periodic intraventricular injections of di*iso*propylfluorophosphate through an indwelling cranial cannula. The preliminary data appear to substantiate the present observations, which suggest that the peripheral enzyme regenerates relatively independently of the cell body. Whether the return of acetylcholinesterase activity along the trunk is a result of newly synthesized enzyme (that is, *de novo* synthesis of protein) occurring in the periphery or a function of one or more conceivable mechanisms of regeneration remains to be elucidated fully (*15*).

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29 April 1960

Relation of Jupiter's Radio Emission at Long Wavelengths to Solar Activity

Abstract. Since the spring of 1960 a strong positive correlation between Jupiter's decametric emission and solar decametric continuum emission observed at Boulder has been evident. The time delay of 1 to 2 days, with solar emission preceding Jupiter's emission, suggests that fast solar corpuscles, at velocities of the order of 0.1 *c*, are directly involved in the planet's atmosphere or magnetic field.

The rate of occurrence of Jupiter's long wavelength emissions appears to have decreased from the time of the discovery observations in 1955 through the period of sunspot maximum, and only this spring has it shown signs of returning to its initial high level. On records made in 1951, Shain (*1*) found many instances of Jupiter emission, following by several years the maximum of the sunspot cycle in 1947. The suggested anticorrelation of Jupiter's emission with sunspot number (*2*) indicates that relatively heavy ionization of Jupiter's atmosphere at sunspot maximum may mask a deep-seated source of emission.

An ionosphere on Jupiter has been widely invoked to explain both the strong polarization of the bursts and the directivity of the source or sources. The magnetic field conditions where the radiation emerges from the ionosphere can be deduced from such observations, and, on the assumption of a limiting cone of emission, the plasma density may also be estimated (*2*, *3*, *4*).

The High Altitude Observatory initiated, on 28 January 1960, a series of observations of Jupiter's decametric emission that have continued until the present. In the period from 28 January to 28 June, emission was detected on 30 separate rotations of the planet. The emission was positively identified and separated from sources of radio interference by the characteristic diurnal motion of the source on our swept-frequency interferometric records. The range of the observations is 15 to 34 Mcy/sec, covered on most of these records in 0.7 second. The total period of observations represented in this interval is about 700 hours, and the minimum detectable flux density at 18 Mcy/sec is about equal to that from the radio source Cassiopeia A—that is, 5×10^{-22} web m^{-2} $(cy/sec)^{-1}$ (*5*).

It was soon apparent on our records that a general correspondence exists between the days of detection of Jupiter's emission and the level of solar activity observed with the radio spectrograph. In particular, strong solar activity in the intervals of 28 March to 4 April and 21 April to 14 May was accompanied by several outstanding occurrences of Jupiter emission. To establish the sug-

gested relation we tabulated those days on which our spectrograph showed evidence for solar radio continuum (*6*). With these dates, 51 in all, as the zero day, we then plotted Fig. 1, showing the rate of occurrence of Jupiter's radio emission before and after solar activity.

The rate of occurrence of Jupiter's emission is higher by 69 percent on the day after solar continuum than the rate for the average day for the 5 month period of these observations. Despite the rather small sample size, the peak at day +1 is significant at the 1 percent level, and the joint probability of observing together both this peak and the peak on day +2 is significant at the 0.1 percent level. Furthermore, the average rate of Jupiter's emission during the 21-day interval of strong solar activity shown on Fig. 1 is significantly higher than the rate for the average of 5 months.

If we assume that during the present apparition Jupiter's emission correlates strongly and positively with solar activity, the question arises concerning the strong emission observed in early 1955 (*7*). Since a similar correlation with decameter solar waves is impossible for this period, we correlated the Zürich provisional sunspot numbers, R_z, from the CRPL-F series reports of 1955 with Burke and Franklin's nine instances of Jupiter's emission during January, February, and March 1955. The result, in Fig. 2, shows as expected a low, but not vanishing, level of solar activity. The spot counts are above average before and below average after day zero, although the differences are marginal in significance. We consider this result to be consistent with our result for this year's data. It does raise a paradox, however, between the prior observations, near sunspot maximum, and the present ones. Systematic effects from several sources, such as increased terrestrial ionosphere and the low elevation of Jupiter above the southern horizon in summer for northern observers, may account for the difficulty.

Low-frequency radio continuum from the sun usually indicates strong solar activity, for example, of the type that often produces noise storms at metric wavelengths or centimetric continuum. Centimetric continuum is intimately connected with the sources of protons that produce polar cap absorptions (*8*). These protons can represent only a part of some large corpuscular stream containing both protons and electrons, which must stream on past the earth at least as far as Jupiter's orbit. Given suitable conditions, presumably the electronic component could directly emit radio waves from the vicinity of Jupiter. The effect of the protons, on the other hand, might be to ionize Jupiter's

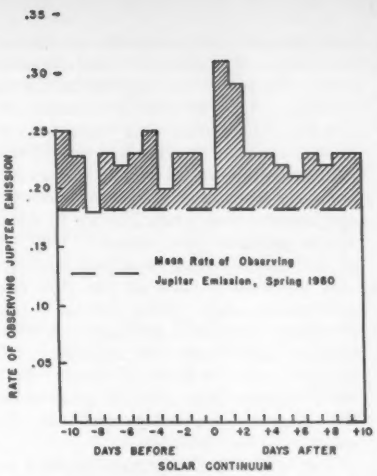

Fig. 1. Correlation between Boulder observations of Jupiter emission and solar continuum, spring, 1960.

atmosphere, in analogy to the terrestrial phenomena. The time delay of about a day, shown in Fig. 1, is evidently consistent with this hypothesis, involving speeds of about 0.1 *c* rather than speeds, one to two orders of magnitude slower, of geomagnetic storm clouds.

That a magnetic field is involved in the decametric emission is demonstrated conclusively by the presence of one state only (the right-handed sense) of circular or elliptical polarization in the bursts (*2*, *9*). The presence of an ionosphere of sufficient density to be important in the radio emission is less certain, despite the existence of possible highly directive emission sources. In fact, Burke and Franklin (*9*), in an often-overlooked remark, noted that the duration of emission periods decreases with decreasing wavelength, contrary to what would be expected of

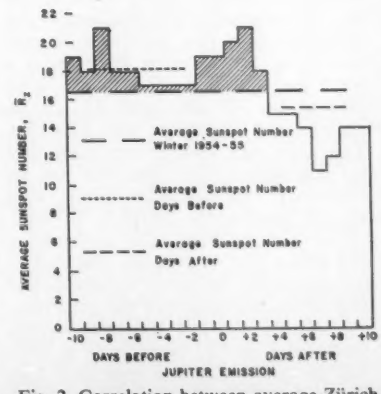

Fig. 2. Correlation between average Zürich sunspot number, R_z, and Jupiter emission, spring, 1955.

an ionosphere. Nevertheless, if we assume that the ionosphere plays an essential role, excited from an internal solar-independent source, we may then conclude that its degree of ionization essentially depends upon the solar corpuscles. The working together of two mechanisms would then be involved—external ionization and internal production perhaps of shocks of some kind.

The need for an internal excitation source has been assumed to follow from the well-defined rotation period of the radio emission centers (*2*). We note, however, that the existent magnetic field, in providing a physical link between the total angular momentum of the planet and external regions of the planet, already provides a uniform rotational basis for the radio sources. If the field is eccentric, the periodicity of the source will be one presentation per rotation, as observed. Such eccentric dipoles certainly occur often in nature, for example, in the sun, the earth, and in certain stars. The presence of an internal excitation mechanism is therefore not a necessary consequence of the constant rotational period.

The observed correlation with solar radio continuum emission, on the other hand, requires that there be present electrons and protons of quite high energy near Jupiter at times when it is emitting. It may be simplest to assume that the decametric emission is produced by either synchrotron or gyro effects and that Jupiter's ionosphere plays no role at all in the emission. Our present spectrographic observations, which sometimes show possible harmonics, suggest that such emitting electrons lie in the region of transition between relativistic and nonrelativistic energy.

If interplanetary high-energy electrons produce Jupiter's decametric emission, we should expect some similar effects for these same electrons when they strike the earth and its magnetic field.

Low harmonics of gyro radiation should occur in the earth's atmosphere as well as in Jupiter's. The radiated energy varies as H^2, however, and if the 20 Mcy/sec Jupiter radiation represents a fundamental, two orders of magnitude less emission is to be expected from the earth. Furthermore, the resulting electromagnetic waves propagate only away from the high-density, high-field regions and out into space. The earth, seen from space, may be a source of sporadic emission in the medium frequency range but comparable to Jupiter in time and manner of emission (*10*).

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25 July 1960

Immunological Technique for Protein Isolation

Abstract. Carefully coagulated antibody or antigen-antibody complexes may be used as specific adsorbents for antigen, and the antigen may be released subsequently by increasing the acidity. No cross adsorption appears to take place. The procedure may prove useful for the isolation of tissue-specific proteins (including those in disease states), toxins, or viruses.

Although authoritative texts (*1*) state that denaturation of antibody destroys its combining sites, the earlier results of Kleczkowski (*2*) and Campbell and Cushing (*3*) indicated that such is not universally the case. The studies discussed below have indicated that antibody may be coagulated by at least seven different agents without destroying or masking all of the specific combining sites, and that the coagulum may be used as a specific adsorbent for antigen. The reagents found effective were the following: ethanol, acetone, hydrochloric acid, sulfuric acid, aluminum chloride, chromic chloride, and heat. If the treatment is too rigorous, all sites are destroyed.

Preliminary tests with 12 other denaturing agents failed to leave any specific activity on the antibody; however, more careful control of the conditions might render these other reagents effective. After adsorption of the antigen at about *p*H 7.0 (batch process with continuous stirring for 2 hours), the coagulum may be washed free of nonspecific protein and the antigen desorbed at *p*H 3.0 to 3.5. The coagulum may be re-used at least 12 times. Samples of coagulated antibody directed against ovalbumin, bovine serum albumin, and keyhole-limpet hemocyanin adsorbed and released their own antigens, but no cross adsorption and release could be detected by interfacial ring tests on the eluates.

The coagulated antigen-antibody complex also was effective as an adsorbent for antigen. The optimum conditions for the coagulation of the complex with ethanol were approximately as follows: 34°C, 90 percent ethanol, *p*H 7.0 for 30 minutes. No cross adsorption of antigen appeared to take place. The coagulum could be used as an adsorbent repeatedly. A representative test showed that when 210 μg of ovalbumin nitrogen were added to 1920 μg of antibody nitrogen to obtain the original precipitate, each of the first five adsorption-elution cycles yielded 40 to 50 μg of ovalbumin nitrogen, adsorbed from a large excess of antigen (1350 μg of nitrogen in 10 ml of saline). This yield suggests that about 5 percent of the original combining sites on the antibody were available.

The utility of the process appears to lie in those circumstances in which a protein exists in only one of two otherwise identical solutions. Such conditions are rather common in biology and medicine. One might contrast normal human serum with the serum of an agammaglobulinemic patient, where gamma globulin is present as an extra component in the normal serum, or one might compare a normal serum with one containing Bence Jones protein, where the abnormal Bence Jones protein is the additional component. The examples need not be as dramatic or as simple as the above, for there are many disease conditions, both acquired and hereditary, where normal proteins are lacking or where abnormal ones appear. In some cases only a single protein may be involved, whereas in others there may be several. Given these prerequisite conditions, it should be possible to isolate the additional component, or components, by a process similar to that described below, wherein ovalbumin has been isolated from a synthetic mixture of ovalbumin and dog serum.

A sample of dog serum was divided into two parts, and to one portion ovalbumin was added, to a concentration of 0.85 mg/ml. The ovalbumin–dog serum mixture was injected into rabbits, 1 ml per injection three times a week for 3 weeks. The rabbits were bled on the 7th day after the last injection, and antiserum was prepared. The antiserum had a very high titer for dog serum (the value was not determined) and contained about 0.26 mg of precipitable antibody to ovalbumin per milliliter. The antibody to dog serum was fractionally adsorbed in the following manner: Unadulterated dog serum was added to the antiserum, the mixture was left 2 hours at room temperature and 22 hours at 0° to 5°C, and the precipitate was spun off. Two hundred milliliters of antiserum were used, and the volumes (in milliliters) of dog serum added were as follows: 5, 5, 5, 10, 10, 10, 20, 20, 20. The last two additions produced no further precipitate.

Table 1. Yield and purity of ovalbumin eluted from a mixture containing 1 part of ovalbumin in 68 parts of dog-serum protein.

Elution No.	Ovalbumin (μg N)	Total protein in eluate (μg N)	Purity of ovalbumin (%)
1	70	125	56
3	47	115	41
5	44	83	53
7	34	58	59

The mixture was then analyzed for antibody to ovalbumin by the quantitative precipitin technique, and the calculated quantity of the ovalbumin–dog serum mixture was added to precipitate the ovalbumin-antiovalbumin complex at equivalence. The resulting precipitate was washed five times and then coagulated by treatment with 90-percent ethanol for 30 minutes at 30°C, *p*H 7.0. The coagulum was washed three times at *p*H 3.0 and three times at *p*H 7.0 to remove the coagulating agent and any uncoagulated complex.

Twenty milliliters of the ovalbumin–dog serum mixture were then added, and the solution was stirred for 2 hours at room temperature. This volume of the mixture contained a large excess of ovalbumin nitrogen (about 2700 μg). All unadsorbed protein, as determined by ring-testing the washes against a portion of the original antiserum, was washed off. The ovalbumin was then desorbed at *p*H 3.1 with buffered saline (0.05*M* glycine-HCl buffer) overnight. The coagulum was spun off, and the supernatant was brought to *p*H 7.0 and analyzed for total protein by the biuret method, and for antigen by quantitative precipitin determinations with a known antiovalbumin antiserum. The coagulum was re-used to adsorb more ovalbumin from a further sample of the same mixture.

As indicated in Table 1, the yield of ovalbumin decreased gradually from 70 to 34 μg of ovalbumin nitrogen over the first seven adsorption-elution cycles. This decrement continued through the 12th cycle (26 μg of nitrogen), when the process was terminated. Data beyond the seventh elution are not included because of the unreliability of the biuret determinations at these low protein levels. The purity of the product averaged a little better than 50 percent. The composition of the impurities has not been studied; however, the possibility exists that part or all of the material may be complement. Since the original ovalbumin–dog serum mixture consisted of one part of ovalbumin nitrogen in 68 parts of dog serum ni-

trogen, the results indicate approximately a 35-fold increase in purity. Further increases in yield and purity should be obtainable as more information becomes available about methods of coagulating the complex and of adsorbing and desorbing the antigen.

As contrasted with the usual physical-chemical methods for protein isolation, this procedure is simple and involves comparatively mild environments for the protein, thus reducing denaturation. In those cases where the procedure is applicable, the method is direct, it depends on a biological property of the protein, and it is highly specific. It should separate proteins with different biological properties but of similar physical-chemical properties, where the conventional techniques would fail. The process may prove useful for the isolation of tissue-specific proteins (including those in disease states), viruses, or toxins (*4*).

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20 June 1960

Continuous Elemental Analysis of Organic Compounds in Gas-Chromatographic Effluents

Abstract. The compounds emerging from the gas-chromatographic column are quantitatively converted to a mixture of CO_2 and H_2. These gases are separated by means of an auxiliary column. The ratio of C and H atoms of each substance is deduced from the areas of carbon dioxide and hydrogen peaks.

A simple method for continuous analysis of the carbon and hydrogen content of volatile compounds previously separated by gas chromatography has been developed.

Substances emerging from a gas-liquid partition column are quantitatively oxidized on copper oxide to form carbon dioxide and water (*1*). The water is reduced to hydrogen by finely divided iron (*2*). Carbon dioxide and hydrogen are then separated by means of an auxiliary column, their concentration in effluent gases being determined by a thermoconductivity cell operated at room temperature.

Thus, two separate peaks, one for carbon dioxide and the other for hydrogen, are obtained for each compound, the ratio between areas under the curves depending on the elementary composition of the substance, independent of its weight.

In the case of hydrocarbons the empirical formula may be directly deduced from the ratio of H_2 and CO_2 peak areas, while with oxygenated compounds only the ratio between carbon and hydrogen atoms is obtained.

The gas chromatograph employed is a model B "Fractovap" of the Società Carlo Erba, Milan, Italy, equipped with stainless steel columns and connected to a model 62 electronic integrator.

The column of the apparatus is connected by means of a silicon rubber fitting to a coiled silica tube 60 cm long, having an internal diameter of 6 mm. This tube is filled in the first section with copper oxide and in the second one with reduced iron on inert support and is heated to 725° ± 10°C by means of an electronically controlled furnace.

Combustion gases are first passed through a 4-m auxiliary column packed with acetonylacetone on Celite C 22 to separate CO_2 and H_2, and then analyzed in a thermoconductivity cell. The conversion of a number of volatile organic compounds (containing C, H, and O) to a mixture of carbon dioxide and hydrogen is found to be quantitative throughout a wide range of experimental conditions (that is, carrier gas flow rate, reaction tube temperature, size of the injected sample, and so on).

Figure 1 shows three typical chromatograms obtained from benzene, cyclohexane, and ethyl ether.

The values for the carbon-hydrogen ratio in the empirical formula of analyzed substances, as deduced from CO_2 and H_2 peak areas, are summarized in Table 1; these values compare favorably with the experimentally derived ratios.

Table 1. Carbon-hydrogen ratios in organic compounds as derived from chromatogram peak areas. Standard deviation of listed values in column 4 is more than 3 percent. Benzene was used for calibration.

Substance	Peak areas (cm^2)		Ratio of peak areas ($H_2 : CO_2$)	Carbon-hydrogen ratio	
	H_2	CO_2		Calculated	Observed
Benzene	634	140	4.53	1.00	1.00
Cyclohexane	515	55.6	9.26	2.00	2.04
Ethyl ether	547	47.9	11.42	2.50	2.52

A small variation in the method's sensitivity—that is, in the ratio of peak areas to sample weight—was observed from day to day. When precise results are required, it is advisable to calibrate the apparatus by means of a standard substance having a known carbon-hydrogen ratio before running a series of analyses.

The proposed method, as compared to the conventional gas-chromatographic technique, offers the remarkable advantage of determining, by means of a thermal conductivity detector, a molecular parameter (such as the ratio of C and H atoms in the empirical formula) which allows, in most cases, direct identification of eluted compounds. Moreover, the detector sensitivity is markedly improved, as long as the katharometer can be operated at low temperature.

From the analytical point of view there is the advantage that separation and carbon-hydrogen ratio determination of such a minute amount as 0.05 mg of an organic substance contained in a complex mixture can be simultaneously performed.

Quantitative combustion, resulting in a mixture of carbon dioxide and hydrogen, of substances separated by gas

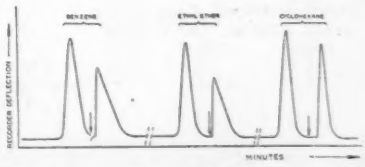

Fig. 1. Analysis of benzene, ethyl ether, and cyclohexane. Main column: 2 m long, internal diameter 6 mm, packed with a mixture of 25 parts by weight of di-*n*-decyl-phthalate on Celite C 22 (40 to 70 mesh). Temperature, 70°C. Auxiliary column: 4 m long, internal diameter 6 mm, packed with a mixture of 28 parts by weight of acetonylacetone on Celite C 22 (40 to 70 mesh). Temperature, 18°C. Carrier gas, nitrogen (flow rate, 0.7 lit./hr). Vertical arrows indicate polarity inversion of potentiometric recorder and sensitivity increase of the thermoconductivity detector. Ratio, 1:4 for benzene and 1:8 for cyclohexane and ethyl ether peaks.

chromatography may also be very useful when a continuous radiometric analysis of effluent gases is desired (*3*), as in the quantitative determination of both C^{14} and H^3 in doubly labeled compounds (*4*).

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25 April 1960

Esters from Bacterial Oxidation of Olefins

Abstract. Identification of esters isolated from culture fluids of bacteria growing upon terminal olefins indicates that bacteria oxidize olefins at the saturated methyl group, leaving the double bond intact. The yeast *Candida lipolytica* produces α-glycols from olefins, presumably by attacking the double bond.

Utilization of straight chain olefins for energy and carbon sources among microorganisms is recognized (*1*), but few data are available to indicate the mechanism involved in the oxidation of these compounds. Bruyn (*2*) isolated *n*-hexadecanediol-1,2 from cultures of *Candida lipolytica* growing at the expense of hexadecene-1. Recent reports (*3–5*) have indicated that paraffins are oxidized by bacteria at the terminal carbon, probably via 1-alkyl hydroperoxide formation. Strains of Gram-negative coccoidal bacteria have been used in the laboratory of the department of bacteriology, State University of Iowa, to study the oxidation of alkanes containing an even number of carbon atoms, from C_{10} to C_{18} (*5*). The organisms grew well when a variety of olefins constituted the sole carbon source, and search was instituted for materials arising from bacterial oxidation of olefins in the liquid culture fluids.

Under conditions similar to those used in prior work (*4*), two strains of the hydrocarbon bacteria grew profusely in minerals–hexadecene-1 media, and a solid material of low melting point was isolated from each of the culture fluids. The material did not respond to any glycol tests but yielded a strongly positive hydroxamic acid test for esters. Growth and ester production were followed (Fig. 1); isolations were carried out at periods of peak ester formation, and the isolated material was subjected to mass spectrometric and infrared analysis (*4*). Mass analysis indicated the material to be an ester of molecular weight 478, with characteristic fragment ions:

$$m/q = 257 \quad (C_{15}H_{31}CO_2H_2^+)$$
$$= 256 \quad (C_{15}H_{31}CO_2H^+)$$
$$= 222 \quad (C_{16}H_{30}^+)$$

The infrared spectrum showed an ester carbonyl group and a sharp absorption peak at 11.0 μ in CCl_4 characteristic of $-CH{=}CH_2$. Thus, the data suggest an ester $C_{15}H_{31}CO_2CH_2(CH_2)_{13}CH{=}CH_2$ (15-hexadecenylpalmitate).

Analysis of material isolated from octadecene-1 cultures proved more difficult to evaluate and indicated the situation with respect to ester formation from the C_{18} olefin to be more complex. Mass spectra of such material showed ions of $m/q = 285$, 271, and 257, with relative intensities 1–2, 7–8, and 2–3, respectively, and of $m/q = 250$, with relative intensity 16. Since $m/q = 250$ would correspond to $C_{18}H_{34}^+$ and $m/q = 285$, 271, and 257 would be $C_{17}H_{33}CO_2H_3^+$, $C_{16}H_{29}CO_2H_2^+$, and $C_{15}H_{31}CO_2H_3^+$, respectively, the mass spectra suggest the product to be a mixture of octadecenyl stearate, octadecenyl margarate, and octadecenyl palmitate in the ratios 1–2 to 7–8 to 2–3. It appears that bacteria attack 1-olefins at the saturated terminal carbon rather than at the double bond and, in the case of this organism, form esters in which the acid moiety is reduced (or totally synthesized via conventional fatty acid synthesizing pathways). These findings are in accord with those of Stewart and Kallio, who found esters (predominantly palmitate) formed from bacterial action on normal alkanes in the even-numbered series from C_{12} to C_{18} (*4*).

The data appear to contradict the observations of Bruyn (*2*), and a reassessment of the action of *Candida lipolytica* on hexadecene-1 was undertaken. After growth of *C. lipolytica* (ATCC 8661) for 5 days on minerals—hexadecene-1 media, ether extraction of culture fluids yielded a white crystalline material identical to that described by Bruyn. Infrared spectra of the isolated material and authentic hexadecanediol-1, 2 were indistinguishable. The isolated compound showed no carbonyl function in its spectrum and was negative to the hydroxamic acid test, but was cleaved by periodic acid. The physical constants of the material isolated were identical with those of authentic hexadecanediol-1,2. Total "diol," as determined by periodate titration, and C, H, and O content were also consistent with the conclusion that the material was essentially pure hexadecanediol-1,2.

It is thus possible to confirm the findings of Bruyn with respect to olefin oxidation by yeast. Evidently there are at least two pathways by which microorganisms initiate oxidation of terminal olefins: by direct attack at the double bond, or via oxidation of the methyl carbon at the saturated end of the molecule (*6*).

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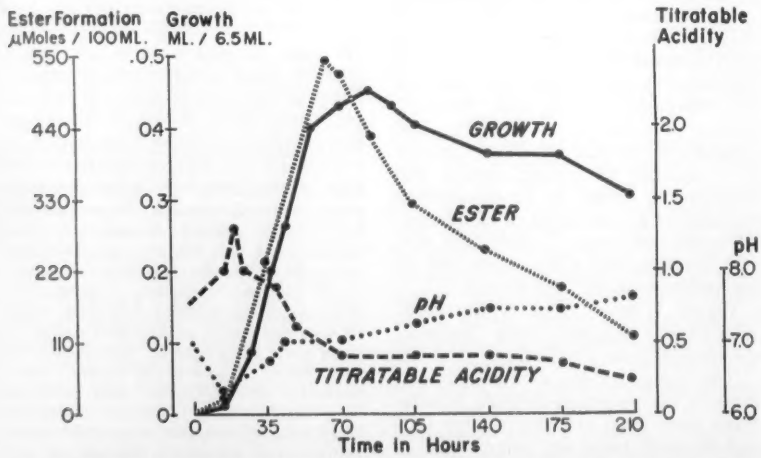

Fig. 1. Growth and ester production of a coccoidal Gram-negative bacterium growing aerobically in a minerals–hexadecene-1 medium. The ester was calculated as equivalents based on the ester group of cetyl palmitate (*4*).

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6 June 1960

Electrophoretic Interaction Studies by the Stable-Flow Free-Boundary Method

Abstract. A new method is described for rapidly mixing and unmixing (separating) components in free solution, enabling studies to be carried out on interactions of the components during their time of contact (presently as short as a few seconds). This method combines a multilayer, stable-flow fluid system with one (or more) transversely acting force fields, commonly an electric field, and is applicable to small molecules, large molecules, and cells.

The stabilized flow system recently reported (*1*) permits continuous electrophoretic separations and concentrations of large sample volumes in free solution without supporting medium. This achievement also permits other preparative and analytical investigations (*2*), including interaction studies, a type of which is the present subject. Several other interesting approaches to continuous solution separations have appeared recently. By isoelectric point immobilization and countercurrent flow, Bier separates the slowest or fastest component of a mixture (*3*). By hyperkinetic sample flow and high-viscosity polymer stabilization, Dobry and Finn fractionate dyes (*4*). [See also Bier's review (*5*)]. In none of these other methods, however, nor apparently in Philpot's early work (*6*), has true flow stability been realized in the sense described below.

A large number of independent, contiguous liquid strata can now be maintained in steady-state laminar flow through a separation (or analytical) apparatus and out into individual containers, with or without simultaneous transverse migration of components under the influence of applied forces. Flow rates from 0 to many milliliters per minute are practical. Flow stability is primarily due to the self-balancing nature of the system, the separate collection containers forming a single hydrodynamic unit with the flow cell. Significant inequities in flow rate (that is, in levels of identical bottles sharing a common horizontal) are thus precluded over a wide variety of operating conditions, that is, the laminar flows are stabilized by "hydrodynamic feedback."

The current apparatus is of the symmetrical 12 inlet–12 outlet form (Fig. 1*A*). Flows are horizontal through the main migration chamber from right to left. Single or multiple samples and background fluids can be injected through a variety of inlet combinations; thus great flexibility of experimental design is obtained. For electrophoresis, a voltage is applied between the top and bottom electrodes (commonly platinum foil or mesh). Force fields other than electric also show promise, but will not be further discussed here. The electrode compartments are hydrodynamically (not electrically) isolated from the main chamber by membranes. Thus, flows through them can be independently varied without disturbing main chamber flows, for example, to prevent diffusion into the main chamber or to set up steady-state *p*H gradients. Pumping is usually by a motor-driven syringe rack, though a much simpler gravity feed system also appears feasible.

Fig. 1*B*, a photograph of a steady-state pattern without electric field (30-cm apparatus), attests to the excellent stability of the different flowing layers. (Spectral analyses on collected fractions also verify this stability.) Similar pictures have been taken with 12 alternating color streams. Cresyl violet enters via inlet No. 5; bromphenol blue, via inlet No. 7. Small density gradients assist in eliminating turbulence that might be caused by uneven pumping, shock, and so forth. Flows pictured are 1.2 ml/min per outlet, 14.4 ml/min over-all. (Sucrose concentrations in inlet streams are: Nos. 1 to 4, none; No. 5, 0.4 percent; No. 6, 0.6 percent; No. 7, 0.8 percent; No. 8, 1.0 percent; Nos. 9 to 12, 2 percent.)

If an electric field is applied to a two-sample system as in Fig. 1*B*, various migration principles can apply. Some discussion of these has already been given (*2*), and it is beyond the scope of the present report to consider them in detail. Suffice it to say that concentrations, *p*H values, densities, flow rates, and field strength can generally be chosen to cause the migration paths of the two components to cross. The time of contact will depend upon the flow rates and electrophoretic migration velocities, both of which can be varied. If during this time, reaction occurs which gives rise to a new component with different properties, it may be separated from the original components at the outlets. If desired, the migration paths after the crossover can be altered by conductivity discontinuities in solution. In the following example, inlet solutions 1 to 4 and 9 to 12 are of higher conductivity than 5 to 8, essentially eliminating further vertical migration of samples above the 4 to 5 and below the 8 to 9 free-boundary positions (*2*, *7*).

Figure 1*C* shows this situation for the dye system of Fig. 1*B*: 0.004 percent cresyl violet enters via inlet No. 5, and 0.001 percent bromphenol blue enters via No. 7 (sucrose concentrations as above). The solution in the

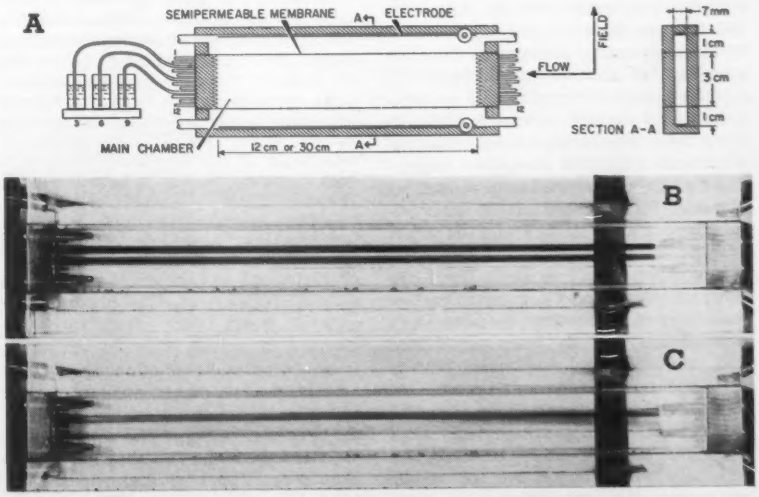

Fig. 1. (*A*) Free-flow apparatus. (*B*) Steady-state flow pattern without electric field. Dye samples admitted through inlets 5 and 7. (*C*) "Crossover" dye experiment with reaction product (middle component) separated at outlet.

top electrode compartment and inlets Nos. 1 to 4 is standard *p*H 4 phthalate buffer diluted 50 to 1 to ionic strength approximately 0.001. In the bottom electrode compartment and inlets Nos. 9 to 12 the solution is standard *p*H 7 phosphate buffer diluted 50 to 1 to ionic strength approximately 0.002; the potential is 11 volts over-all (top positive), the current 1.2 ma; the flow is 1 ml/min per inlet, or 12 ml/min overall. The basic cresyl violet moves down, the unreacted portion appearing as the bottom "ribbon" at the outlet (left). The acidic bromphenol blue migrates upward, its unreacted portion appearing as the uppermost ribbon. During their "crossover" time they react, forming the middle ribbon shown at the outlet. Depending upon initial sample concentrations, the reaction product may be soluble and subject to isoelectric-point stabilization, or it may be (partly) a precipitate with its vertical position stabilized by a suitable density gradient (*2*, *7*). With present apparatus and parameters the contact time during "crossover" can be varied from a few seconds to arbitrarily long times. Thus reactions can be studied over discrete time segments, for instance, during the first few seconds, after which reaction ceases upon unmixing of unreacted or dissociated components. The various layers can be analyzed during flow (for example, optically) or after collection, leading to information on the basic interaction itself.

Where the "reaction product" is a weak complex or association product, the stable-flow free-boundary method may offer unique advantages for its study. Migration in free solution in a relatively low electric field is probably one of the least disruptive procedures one can apply to species under study. Physical properties such as absorption spectra may be but slightly modified by weak complexing, making quantitative study in the mixture very difficult. If, however, such a complex can be completely and rapidly separated while its integrity is preserved, investigation becomes much simpler and more direct.

This dye experiment is presented as a model for macromolecular and cellular interaction studies (for example, enzyme-substrate systems) rather than as a complete study in itself. The feasibility of protein and cellular migration studies by the stable-flow, free-boundary method has already been established (*2*), and additional work with both is now under way. Interaction studies of this general type can to some extent be carried out on supporting media such as paper but the times required are generally much longer and the results not necessarily representative of those in free solution.

In conclusion, it should be emphasized that this work is in its early stages and the theoretical and experimental limits for the method are not yet clearly defined. This multivariable system shares many of the complexities discussed by Dobry and Finn (*4*), and Svensson (*8*). Higher sample concentrations will certainly be desirable for some applications; density-gradient column analyses by Svensson and coworkers are helpful in estimating these possibilities (*8*). Even at this stage, however, it appears to offer a new method for study of interactions in free solutions, including weak interactions, by rapid mixing and unmixing accompanied by low-stress separations of reactants and products (*9*).

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13 June 1960

Chromosomal Polymorphism in the Tumorous-Head Strain of Drosophila melanogaster

Abstract. The Payne inversion is scattered throughout many natural and laboratory populations of *Drosophila melanogaster*. The results of this study show that the majority of flies in the tumorous-head strain are heterozygous for a chromosome containing this inversion and the recessive mutant, scarlet eyes. This chromosome is maintained in the laboratory stock at a high frequency through a heterotic mechanism.

Flies with the tumorous-head trait in *Drosophila melanogaster* are largely characterized by abnormal growths in various regions of the head. These growths, which often appear to be homoeotic in nature, vary in size from small protuberances, affecting a small area of the eye or antenna, to massive amorphous growths occupying most of the head region. Some flies with the trait lack these growths and show an eyeless phenotype. The trait first appeared in 1945 at the University of Texas within a strain of flies that originally came from a sample of a wild population collected at Acahuizotla, Mexico, in 1941. The genetics of the abnormality was first described in 1949 by Gardner and Woolf (*1*). Since that time the trait has been the subject of many articles by Gardner and co-workers. A recent article giving references was published in 1959 by Gardner (*2*).

The genetic mechanism involved consists of a third chromosome, semidominant gene (*tu-3*) in the right arm at about position 58, and a sex-linked recessive gene (*tu-1*) near or in the heterochromatic region, which is responsible for a maternal effect (*2*). The tumorous-head strain, which is homozygous for *tu-1* and *tu-3*, is symbolized by *tu-h*.

Experiments have shown that the recessive gene for scarlet eyes (*st*), located at position 44 in the left arm of the third chromosome, is found in the heterozygous condition in the majority of the flies of the strain. From 300 single-pair matings between *tu-h* and *st* flies, offspring were obtained in 251 of the cultures. A total of 37 of the cultures showed all nonscarlet offspring, while 214, or 85 percent, showed segregation for scarlet and nonscarlet. A sample of 2716 flies from these latter cultures yielded 1389 nonscarlet and 1327 scarlet, which approximates a 1:1 ratio ($0.20 < P < 0.30$).

The results of these crosses indicate that there are two different third chromosomes in the flies of the *tu-h* strain. The chromosome not containing scarlet was tentatively called IIIA, while the one containing scarlet was symbolized by IIIB. The above results also suggest that IIIB is homozygous lethal since the scarlet phenotype does not occur in any of the flies in the *tu-h* strain. This was demonstrated experimentally from matings between *tu-h* flies and those with the following third chromosome markers: *ru h* D^s *st ri InRC e l3e/Me*^{r} *Ins ri* Sb^t. From the progeny, flies were selected that were nonscarlet, dichaete (IIIA/*ru h* D^s *st ri InRC e l3e*) and scarlet, dichaete (IIIB/*ru h* D^s *st ri InRC e l3e*). Each type was then inbred in an attempt to obtain nondichaete offspring that were IIIA/IIIA and IIIB/IIIB. The IIIA/IIIA types were found in the expected frequency but the offspring from the other cross were all scarlet, dichaete, like the parents, indicating the lethality of the IIIB chromosome when homozygous.

Evidence for the presence of an inversion in the left arm of the IIIB chromosome came from crossing females that were IIIA/*ru h th st* p^p *cu sr* e^a *ca* and IIIB/*ru h th st* p^p *cu st* e^a *ca* with *ru h th st* p^p *cu sr* e^a *ca* males. Crossing-over occurred along the entire length of the IIIA chromosome but was suppressed in the left arm of the IIIB chromosome. The salivary gland chro-

mosomes of IIIB/*ru h D*^{s} *st ri InRC e l3e* heterozygotes were then examined. A large paracentric inversion was observed in the left arm of the IIIB chromosome with distal and proximal breaks corresponding to those for the Payne inversion (*3*), symbolized by *In(3L)P*.

Genetic evidence for the presence of the Payne inversion in the *tu-h* strain was obtained by crossing IIIB/*ru h D*^{s} *st ri InRC e l3e* flies with those with the markers *R Ly/In(3L)P*, and picking out in the offspring flies that were IIIB/*In(3L)P*. These flies were viable, showing that different lethals are associated with the two chromosomes. Inbreeding these types gave rise to about 30 percent recombinant scarlet offspring, resulting from the freeing of *st* by crossing-over from the lethal or lethals associated with the left arm of the IIIB chromosome. The occurrence of scarlet offspring demonstrates that pairing of the chromosomes in meiosis is normal and, therefore, that the inversion in the IIIB chromosome is *In(3L)P*.

The Payne inversion is widespread in many natural populations and laboratory stocks of *Drosophila melanogaster* (*3*). The interesting problem is what advantage the chromosome containing this inversion bestows upon its bearers in the *tu-h* strain, for it represents a remarkable case of natural selection for the heterozygote in a laboratory population. All *tu-h* strains maintained at the University of Utah contain the IIIB chromosome, and from the results of outcrosses the scarlet gene is known to have been heterozygous in all these strains since at least 1951. The techniques of maintaining the stocks have varied over the years. In some generations flies showing the tumorous-head trait have been selected as parental types; in others, mass mating procedures have been employed. Under either method, and even when the number of parental flies utilized has been small, the IIIB chromosome has been kept at a high frequency. The suppression of crossing-over in the left arm of chromosome III by the Payne inversion has likely led to the establishment of a heterotic mechanism.

Since the *tu-1* gene has been found in the homozygous condition in several different natural and laboratory populations (*4*), it seems likely that the original flies collected in Mexico possessed *tu-1* and were also undergoing segregation for the Payne inversion. The mutations to *tu-3* and *st* occurred later in the laboratory stock, although *st* might have been present on the same chromosome as the inversion in the original flies.

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21 September 1960

Appearance of Genetic Transforming Activity in Pneumococcal Cultures

Abstract. Growing populations of *Pneumococcus* were found to release into the culture medium deoxyribonucleate-containing material with genetic transforming activity. Active material was maximally produced at the time when the culture was most responsive to added deoxyribonucleate. Since mixed cultures thus give rise to recombinants, it may be that transformation provides a natural mechanism of genetic recombination for *Pneumococcus*.

In 1944, Avery, MacLeod, and McCarty (*1*) established the genetic transforming principle of *Pneumococcus* to be deoxyribonucleic acid. Since that time most transformations, in pneumococci and in other transformable bacteria, have been carried out with purified soluble deoxyribonucleate, with the principal exception of the lysate transformation system described by Hotchkiss (*2*). In this system, penicillin, or later streptomycin, was used to kill sensitive organisms carrying a suitable genetic marker. If appropriate recipient cells resistant to the drug were mixed with the sensitive population, a fraction of the resistant recipients were transformed by genetic material from the dying population. This method was used mainly as a tool for simplified transformation tests until we recently began investigations on genetic and physiologic aspects of transformation by lysed cells.

The bacteria used in this investigation were pneumococcal strain R_6 [a single-colony derivative of R36A (*1*)] and derived variants genetically resistant to streptomycin, sulfonamide, micrococcin, and amethopterin, singly or in combination. These variants were obtained by transformation of the R_6 wild type with the appropriate deoxyribonucleate extracted from cultures of spontaneously arising resistant mutant strains.

Deoxyribonucleate was prepared by the method described by Hotchkiss (*3*), based on the method of McCarty and Avery (*4*). The bacteria were grown in a casein hydrolyzate medium enriched with vitamins, minerals, glucose, bovine serum albumin, and neopeptone. Cultures to be used as recipients were frozen at −20°C in 10-percent glycerol when they had reached the transformable state (*5*) and maintained at this temperature. The frozen cultures retained their transformability during 2 to 3 months of storage.

Bacteria to be used as donors were freshly grown (starting with an inoculum from a culture thawed at 0°C) on the day of use. Total population size and number of transformants were estimated by colony counts in broth containing specific antibody in the presence of which each viable unit grows as a visible aggregate (*6*). Transformations were initiated by exposing the freshly thawed diluted recipient cells to donor material for 30 minutes at 30°C (*5*). At this time pancreatic deoxyribonuclease was added to terminate the reaction by destroying any deoxyribonucleate not taken up by the cells. The cultures were then incubated at 37° for 30 to 90 minutes to permit expression of the newly acquired traits, after which aliquots were diluted into the appropriate scoring medium. Colonies were counted after 16 to 20 hours' incubation at 37°C. When cells were to be separated from culture fluid, Millipore filters of porosity 0.45 ± 0.02 μ (Millipore Filter Corp.) were used.

During the course of experiments on the mechanism of streptomycin-induced lysate transformation it was found that cell-free filtrates of control cultures not treated with drug, and therefore presumably normal, were often able to effect transformation of recipient cultures. When this phenomenon was investigated further it was found that all of the drug-resistance properties mentioned earlier could be regularly induced in recipients by using filtrates of appropriate living cultures, and that the activity in the filtrates was probably due to some deoxyribonucleate-containing material, since it, like the activity released by drugs, could be destroyed by pancreatic deoxyribonuclease. The deoxyribonucleate in such material was of sufficient intactness to transfer linked determinants of sulfonamide resistance (*6*), the frequency of double transformants being as much as 1000 times that expected on the basis of chance.

It was also found that the amount of active transforming material present in any culture filtrate was related to the stage of growth, the maximum activity appearing at about the middle of the logarithmic phase (about 2×10^7 colony-forming units per milliliter). Because transforming activity and the stage of growth of the culture were clearly related, and because transformability by exogenous deoxyribonucleate also varies with stage of growth of the culture, it was of interest to study the relation between the abilities to serve as

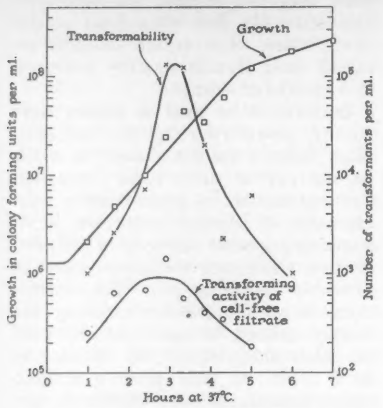

Fig. 1. Transformation by culture filtrates. The transformability of a growing culture of sulfonamide-resistant cells was tested with deoxyribonucleate carrying streptomycin resistance, at the times shown. At the same times, filtrates of the culture were prepared and used to transform sulfonamide-sensitive cells to sulfonamide resistance. On occasion, as many as 1 percent of the cells are transformed by culture filtrates in such experiments. This represents about one-tenth of the maximum yield obtainable by isolated deoxyribonucleate under comparable conditions.

donor and as recipient in the same culture. The results of one experiment are illustrated in Fig. 1. It appears that at a time in growth when a population is producing the greatest quantity of material for transforming other cells, the population is itself most susceptible to transformation.

The correlation in time between production of transforming activity and transformability need not, of course, imply a causal relationship between the two functions, either within the population or in individual cells. We have evidence, however, that with growth there is released into the culture medium some factor which interferes with transformation by added isolated deoxyribonucleate, although it does not clearly behave like a deoxyribonuclease. This effect is being investigated further and may explain in part the reduction in the transforming activity of late filtrates and even the decrease in transformability of pneumococcal cultures allowed to grow beyond a certain point.

The coincidence in time of maximum transformability and maximum production of transforming activity made it feasible to attempt the recovery of recombinants from differently marked cultures grown in each other's presence. The results of one mixed-growth experiment are presented in Fig. 2. Two cultures, one resistant to sulfonamide and amethopterin, the other resistant to streptomycin and micrococcin, were inoculated into the same culture tube. Transformants having resistance to three drugs were scored in aliquots of the culture at different times during growth. Since the determinants, being unlinked, are normally transferred singly, it was possible to detect the direction of transformation. It is evident that each culture was able to donate both of its markers and to accept both markers of the other culture (*7*).

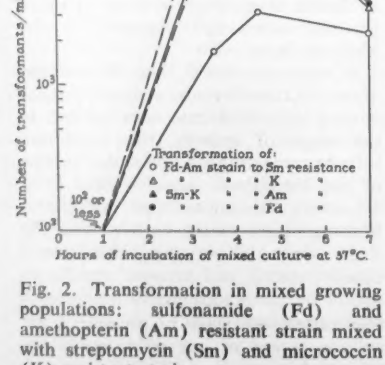

Fig. 2. Transformation in mixed growing populations: sulfonamide (Fd) and amethopterin (Am) resistant strain mixed with streptomycin (Sm) and micrococcin (K) resistant strain.

These experiments indicate that extracellular deoxyribonucleate-containing material can be found in growing pneumococcal cultures. Several authors have reported the accumulation of extracellular deoxyribonucleate in cultures of other bacteria, such as some halophilic bacteria (*8*), *Brucella* (*9*), *Micrococcus* (*10*), *Alcaligenes* (*10*), *Pseudomonas* (*10*). *Flavobacterium* (*10*), and *Neisseria* (*11*). In such cultures, however, deoxyribonucleate accumulated very late in the growth cycle, or else under unfavorable growth conditions, and was produced in such abundance (about 100 mg per liter of culture for *Neisseria*) that the growth became visibly slimy. In the case of *Neisseria meningitidis*, Catlin (*11*) also demonstrated that the extracellular deoxyribonucleate had transforming activity similar to that of deoxyribonucleate extracted from cells. Both Takahashi (*12*) and Catlin (*11*) attributed the accumulation of extracellular deoxyribonucleate to death and lysis of a fraction of the population, and Catlin (*10*) also proposed that the production of significant amounts of an active deoxyribonuclease-inhibitor (a ribonucleic acid) by some cultures might explain why such an accumulation occurred.

The situation in *Pneumococcus*, however, seems to be quite different, because deoxyribonuclease-sensitive material with transforming activity is maximally produced relatively early in growth under presumably favorable conditions and does not accumulate in large amounts. The absence of activity in older pneumococcal cultures and the failure to accumulate deoxyribonucleate may be due to the increased production, with growth, of material which destroys active deoxyribonucleate. Although studies on other organisms, such as *Escherichia coli* (*13*), seem to indicate that cell death is rare during active growth of the population, we have not yet been successful in determining whether for pneumococci the transforming material released by growing cultures comes from population turnover or from active excretion by living cells. Nonetheless, the existence of such material in pneumococcal cultures lends support to the idea that transformation may not be a phenomenon restricted to laboratory conditions. As pointed out in 1951 (*2*), in a mixed population under strongly adverse environmental conditions, lysate transformation might prevent the total loss of the genome of the sensitive organisms present. Now, the presence of transforming material, and the correlation between transforming activity and transformability in growing populations, make it seem quite possible that transformation in *Pneumococcus* may provide a natural mechanism of genetic recombination for an organism in which, so far, no other such mechanism has been found.

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20 June 1960

Association Affairs

Preview of Programs at AAAS New York Meeting

Some of the programs to be presented at the 1960 AAAS meeting in New York are given here. Others will be announced in subsequent issues. Further information can be found by referring to the following articles which have appeared in previous issues of *Science*: "Preliminary announcement of the New York meeting" [**131**, 1616 (27 May 1960)]; "Additional program notes, hotel headquarters, and housing for the New York meeting" [**132**, 228 (22 July 1960)]. The meeting will be one of the largest in recent years.

Mathematics

Section A. Vice-presidential addresses: "Mappings on Sequence Spaces," by Gustav A. Hedlund, Yale University; "The Training of College Teachers of Mathematics and Science," by William L. Duren, Jr., University of Virginia. Symposium: "The Mathematics Course on 'Continental Classroom'," 27 Dec.; William L. Duren, Jr., presiding. Papers will be presented on modern algebra (J. L. Kelly, University of California, Berkeley); probability and statistics (Frederick Mosteller, Harvard University); the teacher-education program (Julius H. Hlavaty, DeWitt Clinton High School); problems of the producer (Marvin Einhorn, National Broadcasting Company).

Section A is a cosponsor of the programs of the Society for Industrial and Applied Mathematics and the Association for Computing Machinery.

Society for Industrial and Applied Mathematics. Invited papers: "Mathematics Looks at New Problems," arranged by James H. Griesmer, IBM Research Center, who will preside; 28 Dec. Papers will be presented on applications of game theory to military strategy and tactics (Dean Gillette, Bell Telephone Laboratories); an application of graph theory to group dynamics (Frank Harary, University of Michigan); the role of mathematics in control systems (John E. Bertram, IBM Research Center).

Association for Computing Machinery. Invited papers: "Vistas in Digital Computing," arranged by a committee, J. H. Wegstein, National Bureau of Standards, chairman, with W. F. Cahill, National Aeronautics and Space Administration, presiding; 29 Dec. Papers will be presented on the effect of adjusting parameter-estimates in decision models (Shiv Gupta, Case Institute); computers and information retrieval—progress and prospects (Ascher Opler, Computing Usage Company, Inc.); use of computers in biology and medicine (Robert S. Ledley, National Biomedical Research Foundation, Inc.).

American Mathematical Society. Cosponsor of a four-session symposium, "The Sciences in Communist China," arranged by a committee, Sidney H. Gould, American Mathematical Society, chairman, with George R. Harrison, Massachusetts Institute of Technology, presiding; 26 and 27 Dec. Part I, "Mathematics and the Physical Sciences," includes a paper on mathematics by Marshall Stone, University of Chicago.

Attention is also called to the following programs: a symposium, "Machine Processing in Education," Dec. 29, sponsored by Section Q–Education; a symposium, "Machine Methods in Biology," Dec. 30, sponsored by Section G–Botanical Sciences.

Physics

Section B. Interdisciplinary symposium, joint program of Sections B–Physics and D–Astronomy, cosponsored by the American Astronomical Society, the Division of Plasma Physics of the American Physical Society, and Sigma Pi Sigma: "Plasma—Fourth State of Matter," arranged by Stanley S. Ballard, University of Florida, with Lyman Spitzer, Jr., Princeton University, presiding; 28 Dec. Papers will be presented on the nature of a plasma (Melvin D. Gottlieb, Princeton University); instabilities in laboratory plasmas (Stirling A. Colgate, Lawrence Radiation Laboratory); radio noise from solar plasmas (Fred T. Haddock, University of Michigan Observatory); geomagnetic storms, aurorae, and radiation belts (Thomas Gold, Cornell University).

Panel, joint program of Sections B–Physics and M–Engineering: "The Place of Nuclear Engineering in the University Curriculum"; 30 Dec.

Physicists' luncheon and vice-presidential address of Section B (in joint session with Sigma Pi Sigma) on "Basic Science in the NATO Family of Nations," by Frederick Seitz, University of Illinois; 30 Dec.; arranged by Lyle B. Borst, New York University.

American Astronautical Society. First annual Eastern regional meeting: Ross Fleisig, Sperry Gyroscope Company, program chairman. Presidential introduction and welcoming address by George R. Arthur. Symposium, cosponsored by the National Aeronautics and Space Administration: "Lunar Exploration"; 27 Dec.; Hugh L. Dryden, National Aeronautics and Space Administration, presiding. Papers will be presented on scientific objectives of lunar exploration (Robert Jastrow, National Aeronautics and Space Administration); distribution of interplanetary dust in cislunar space (S. F. Singer, University of Maryland); comparison of special perturbation methods in celestial mechanics with special application to lunar orbits (Samuel Pines, Republic Aviation Corporation).

Symposium: "Lunar Spacecraft Systems"; 27 Dec.; Robert Young, ACF Industries, Inc., presiding. Papers will be presented on a family of radioisotope-fueled auxiliary power supplies for lunar exploration (Justin L. Bloom, the Martin Company); extending the range of radar beacon tracking for lunar probes (Norman S. Greenberg, ACF Industries, Inc.); horizon trackers for lunar guidance and control systems (K. H. Kuhn, Sperry Gyroscope Company); lunar soft landing guidance sensors (Gordon Burton and Arthur Barabush, Raytheon Company).

Panel discussion: "Is There a Need for a Manned Space Laboratory?"; 27 Dec.; Alfred M. Mayo, National Aeronautics and Space Administration, moderator.

American Institute of Physics. Cosponsors of the four-session symposium, "The Sciences in Communist China," to be held 26 and 27 Dec. Part I, "Mathematics and the Physical Sciences," includes a paper on physics (Ta-You Wu, National Research Council, and Robert T. Beyer, Brown University) and a paper on geophysics of the solid earth (J. Tuzo Wilson, University of Toronto).

American Meteorogical Society. Cosponsor of the symposium, "The Sciences in Communist China." Part II, "Meteorology and the Engineering Sciences," includes a paper on meteorology, hydrology, and oceanography by Malcolm Rigby, of *American Meteorological Society, Abstracts*.

Chemistry

Section C. Session for submitted papers, with the assistance of the New York Section, American Chemical So-

ciety, arranged by Seymour L. Meisel, Socony Mobil Oil Company, who will preside; 26 Dec.

Biochemistry and Organic Chemistry Symposium, with the assistance of the New York Section, American Chemical Society: "Mechanism of Action of Antitumor Agents," arranged by Charles C. Price, University of Pennsylvania, who will preside; 27 Dec. Part I: Papers will be presented on 6-mercaptopurine (M. Earl Balis, Sloan-Kettering Institute); azaserine (John M. Buchanan, Massachusetts Institute of Technology); folic acid antagonists (Charles A. Nichol, Roswell Park Memorial Institute). Part II: Papers will be presented on fluorinated pyrimidines (Charles Heidelberger, McArdle Memorial Laboratory); alkylating agents (Charles C. Price and Robert J. Rutman, University of Pennsylvania); cyclophosphamide (Orrie M. Friedman, Brandeis University).

A dinner for symposia chairmen, speakers, and guests will be held 27 Dec.

Polymer Chemistry Symposium, with the assistance of the New York Section, American Chemical Society: "Recent Advances in Polymer Chemistry," arranged by Charles G. Overberger, Polytechnic Institute of Brooklyn, who will preside; 29 Dec. Part I: papers will be presented on Diels-Alder polymers (J. M. Whelan, Union Carbide Plastics); kinetic investigation of the solution polymerization of propylene (Donald F. Hoeg, W. R. Grace and Company); aromatic polyethers (Charles C. Price); polyaromatics (James E. Mulvaney, Herward Vogel, Takayuki Otsu, Clause J. Abshire, M. Hasegawa, C. S. Marvel, University of Illinois). Part II, arranged by Robert Ullman, Polytechnic Institute of Brooklyn, who will preside; papers will be presented on high resolution nuclear magnetic resonance spectroscopy of polymers (F. A. Bovey, Minnesota Mining and Manufacturing Company); the stretching of crystalline polymers (R. S. Stein, University of Massachusetts); some studies of the secondary structures of ribonucleic acid (J. Fresco, Princeton University); polymerization in the crystalline state (Herbert Morawetz, Polytechnio Institute of Brooklyn).

Inorganic Chemistry Symposium, with the assistance of the New York Section, American Chemical Society: "Synthetic Zeolites," arranged by George T. Kerr, Socony Mobil Oil Company, who will preside; 29 Dec. Papers will be presented on electrical conductivity of synthetic zeolites (Dennis N. Stamires, the Linde Company); crystal structures of Ca-H_2O-chabazite, dry Ca-chabazite, and Ca-Cl_2-chabazite (Joseph V. Smith, University of Chicago); continuous and discontinuous changes in zeolite structure (Rustum Roy, Pennsylvania State University); kinetics of crystal growth of zeolite A (George T. Kerr).

Inorganic Chemistry Symposium, with the assistance of the New York Section, American Chemical Society: "Reactions of Complexes," arranged by John C. Bailar, Jr., University of Illinois, who will preside; 30 Dec. Papers will be presented on substitution reactions of metal complexes (Fred Basolo, Northwestern University); mechanisms of racemization of complexes (Gordon Harris, University of Buffalo); catalytic racemization of complexes (W. Conard Fernelius, Koppers Company); reactions of coordinated ligands (Daryle H. Busch, Ohio State University).

American Association of Clinical Chemists. Contributed papers I, arranged by Harry Goldenberg, Hillside Hospital, with Julius J. Carr, Methodist Hospital of Brooklyn, moderator; 26 Dec. Contributed papers II, arranged by Harry Goldenberg, with Abraham Saifer, Isaac Albert Research Institute, moderator; 27 Dec.

Annual business meeting, New York-Metropolitan Section, AACC, with Jacob Kream, chairman; 26 Dec. The session will include discussion of activities at the International Congress of Clinical Chemistry in Edinburgh and at the joint meeting of the American and Canadian societies in Montreal.

Symposium: "Biochemical Applications of Gas Chromatography," arranged by Harry Goldenberg, Hillside Hospital, with Donald A. M. MacKay, Evans Research and Development Corporation, moderator; 27 Dec. Introductory remarks (Donald A. M. MacKay); presentation of papers on analysis of steroids (E. C. Horning, National Heart Institute, U.S. Public Health Service); analysis of bodily metabolites (E. O. A. Haahti and W. J. A. Vandenheuvel, U.S. Public Health Service); gas chromatography of solid organic compounds (W. D. Cooke, Cornell University).

The AACC dinner and reception will be held 27 Dec., with Albert E. Sobel, Jewish Hospital of Brooklyn, presiding.

American Chemical Society. Cosponsor of the four-session symposium, "The Sciences in Communist China," to be held 26 and 27 Dec. Part I, "Mathematics and the Physical Sciences," includes a paper on chemistry by Arthur Yu, Thiokol Chemical Corporation. Part II, "Meteorology and the Engineering Sciences," includes a paper on chemical engineering and metallurgical and mining engineering by L. C. Pan, Chemical Constructions Corporation.

Astronomy

Section D. Interdisciplinary symposium, joint program of Sections D–Astronomy and B–Physics, cosponsored by the American Astronomical Society, the Division of Plasma Physics of the American Physical Society, and Sigma Pi Sigma: "Plasma—Fourth State of Matter," arranged by Stanley S. Ballard, University of Florida, with Lyman Spitzer, Jr., Princeton University, presiding; 28 Dec. Papers will be presented on the nature of a plasma (Melvin D. Gottlieb, Princeton University); instabilities in laboratory plasmas (Stirling A. Colgate, Lawrence Radiation Laboratory); radio noise from solar plasmas (Fred T. Haddock, University of Michigan Observatory); geomagnetic storms, aurorae, and radiation belts (Thomas Gold, Cornell University).

Section D is cosponsor of the symposium of the American Geophysical Union, "The Impact of the Space Program on the Sciences," to be held 26 Dec. It is also cosponsoring the session of the National Science Teachers Association on "The New Astronomy," to be held 28 Dec. Ruth E. Cornell, Wilmington (Del.) Board of Education, will preside; Wesley S. Krogdahl, University of Kentucky, will be the speaker. The session will include a panel discussion.

The vice-presidential address, "Problems in Future Telescope Design," will be given 29 Dec. by Ira S. Bowen, Mount Wilson and Palomar Observatories, with Nicholas U. Mayall, Lick Observatory, presiding.

American Astronomical Society. Cosponsor of the AGU symposium, "The Impact of the Space Program on the Sciences," to be held 26 Dec. Council meeting, parts I and II, 28 Dec. Sessions for contributed papers I and II, 29 Dec.; III and IV, 30 Dec. The Helen B. Warner Lecture, by Halton C. Arp, Mount Wilson and Palomar Observatories, will be delivered on 29 Dec. The Society dinner will be held on 30 Dec.

All sessions of the American Astronomical Society are jointly sponsored by Section D–Astronomy.

Attention is called to the following programs: An address, "Recent Work on Meteorites," by Edward Anders, 1959 winner of the AAAS Newcomb Cleveland Prize, 26 Dec.; a paper on astronomy by Frank Bradshaw Wood, in part III ("Astronomy and the Biological and Medical Sciences") of the four-session symposium on the sciences in Communist China, 27 Dec.; the program of the American Astronautical Society, 27 Dec. (See Section B.)

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The General Program of the 127th Meeting of the AAAS in New York, 26–31 December 1960, will be available to you, at cost, within the first week in December—whether you can attend the Meeting or not.

Program Content

1. The two-session AAAS General Symposium, "Moving Frontiers of Science V"—Speakers: Edward Anders, H. W. Magoun, George Wald, and H. H. Goldstine; Thomas Park, presiding.
2. The "Challenge to Science" evening with Sir Charles P. Snow, Theodore M. Hesburgh, and W. O. Baker; Warren Weaver, presiding.
3. On "AAAS Day," the three broad, interdisciplinary symposia—Plasma: Fourth State of Matter; Life under Extreme Conditions; and Urban Renewal and Development, arranged by AAAS Sections jointly.
4. The Special Sessions: AAAS Presidential Address and Reception; Joint Address of Sigma Xi and Phi Beta Kappa by Polykarp Kusch; the Tau Beta Pi Address; National Geographic Society Illustrated Lecture; and the first George Sarton Memorial Address by René Dubos.
5. The programs of all 18 AAAS Sections (specialized symposia and contributed papers).
6. The programs of the national meetings of the American Astronomical Society, American Nature Study Society, American Society of Zoologists, History of Science Society, National Association of Biology Teachers, Scientific Research Society of America, Sigma Delta Epsilon, Society for General Systems Research, Society for the Study of Evolution, Society for the History of Technology, Society of Systematic Zoology, and the Society of the Sigma Xi.
7. The multi-sessioned special programs of the American Association of Clinical Chemists, American Astronautical Society, American Geophysical Union, American Physiological Society, American Psychiatric Association, American Society of Criminology, Association of American Geographers, Ecological Society of America, Mycological Society of America, National Science Teachers Association, New York Academy of Sciences—and still others, a total of some 90 participating organizations.
8. The four-session program of the Conference on Scientific Communication: The Sciences in Communist China, cosponsored by the AAAS, NSF, and ten societies.
9. The sessions of the Academy Conference, the Conference on Scientific Manpower, and the conference of the American Council on Women in Science.
10. The sessions of the AAAS Cooperative Committee on the Teaching of Science and Mathematics, and of the AAAS Committee on Science in the Promotion of Human Welfare.
11. Titles of the latest foreign and domestic scientific films to be shown in the AAAS Science Theatre.
12. Exhibitors in the 1960 Annual Exposition of Science and Industry—103 booths—and descriptions of their exhibits.

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Letters

Rainbow Bridge

A. M. Woodbury [*Science* **132**, 519 (26 Aug. 1960)] certainly made his point that any of the proposed engineering works designed to protect the Rainbow Bridge would result in permanent disfigurement that would be even worse than the damage they are designed to prevent. It seems foolish to push this approach to the problem when such a result can be clearly foreseen.

This, however, leaves the present plans which will extend an arm of the Glen Canyon Reservoir into the monument in clear violation of the provision of the law as quoted by Woodbury. The actual dilemma, whether or not to violate these provisions of the law, would seem on first sight, at least, not at all difficult to solve. To have, at no time, water backed up under the Rainbow Bridge, the Glen Canyon Dam would simply have to be, according to Woodbury's figures, 46 feet lower than planned. It is not clear how much more would have to be cut off the height of the dam in order to protect the monument completely. It is obvious, more so than ever after reading Woodbury's article, that having this magnificent country unimpaired would be a far greater asset to the U.S. than having the additional water storage capacity provided by the top 75 feet or so of the dam. It is also clear that no encroachment on the national park system should be permitted. Lowering the level of the top of the dam would avoid damage to these values and would also undoubtedly make the dam cost less, thus saving the taxpayers' money.

F. R. FOSBERG

Nature Conservancy, Washington, D.C.

The question raised in F. R. Fosberg's letter does not lie within the purview of my article dealing with the protection of Rainbow Bridge, but something about the background of the dam may be worth while.

As I understand it, the dam was planned so that the investment would yield its greatest economic return. The dam could have been higher or lower, but deviation from its present planned height would reduce its economic efficiency. Once the height of the dam was determined, then engineering plans and specifications were drawn to fit the height. Construction of the dam is under way. The foundation is being laid, the cliff faces are ready, and the overflow outlet tunnels at the planned height are partly complete. Reducing the height of the dam at this stage of construction would require expensive modifications. To make these changes would require alteration of the foundation design, further work on the cliff faces, drilling of new overflow outlet tunnels, revision of all contracts for the work, and redesign of power outlets and turbines.

Instead of saving taxpayers' money, the alterations would greatly increase the cost, thus making the whole project more expensive as an investment. The problem of getting the approval of Congress for the change and the cost of redesigning the dam by engineers would run the expenditure sky high. A loss of 75 feet in height of the dam would decrease by 48 percent the active storage capacity of the reservoir and reduce its effectiveness in regulating stream flow.

Fosberg's question still remains. Obviously, if change in the height of the dam is impractical and it is senseless to disfigure the surrounding scenic landscapes to protect the bridge, then the only sensible thing left to do seems to be to incorporate the bridge into the proposed national recreation area and leave the problem in the hands of the National Park Service.

ANGUS M. WOODBURY

Division of Biological Sciences, University of Utah, Salt Lake City

Intramural Research

A recent issue of *Science* [**132**, 75 (8 July 1960)] carried a news article entitled "Basic research in the Defense Department: the department's view," in which the research and development budget of the Department of Defense was discussed in relation to basic research. Unfortunately, both the report and its title suggest that all the department's basic research is done elsewhere; intramural research is completely ignored.

It should be well known that there are a number of active research laboratories within the military establishment, that they cover a variety of scientific fields, and that they carry on considerable basic, as well as applied, research, much of which is published in scientific journals. Financial problems have been even more serious for them than for the over-all research program since, at a time when the department's total research and development budget is slowly increasing, these laboratories have had their allotments reduced and are having to curtail activities to adjust to this reduction as well as to increasing costs of both goods and services.

A discussion of the value and support of intramural research in the Department of Defense would be out of place in this letter, since it would involve considerations of social and political attitudes as well as of competition for prestige and funds. However, the almost complete lack of awareness of the problems on the part of the scientific community can hardly lead to any intelligent handling of the situation.

DAVID E. GOLDMAN

Naval Medical Research Institute, Bethesda, Maryland

Disarmament

The news article entitled "Thinking about disarmament" [*Science* **132**, 282 (29 July 1960)] demonstrates to me the utterly naive concepts about the world in which we live that are apparently held by some scientists engaged in research on "disarmament." Of course Morgenthau is right in believing that valid national interests may be protected by an international judiciary with the power to enforce its decisions, but I would challenge the other side of the coin—the view which implies that in the absence of such a judiciary a nation can protect its interests by the use or threat of use of military power.

In this ICBM–H-bomb age in which we live the only sane goal seems to me to be one that has recently been aptly stated by Adlai Stevenson. "One of the two main preconditions of peaceful human society [is] economic solidarity and mutual help. The other precondition of peace—and this, of all priorities, is our highest—is our unwavering search for peace under law which, in our present context, means controlled and supervised disarmament. Only a disarmed world offers us security worth the name any longer."

If the scientists, and others, who are "thinking about disarmament" would accept this as the goal toward which American foreign policy should be directed we could, I believe, begin to spell out the kind of world institutions (executive, legislative, and judicial) which alone stand a chance of creating a just and peaceful world.

This is not meant to suggest that unilateral destruction of nuclear stockpiles tomorrow is the answer or that total disarmament under enforceable world law will be easy to achieve, but rather to decry the emphasis on such limited, and I feel provocative, objectives which suggest—on the basis of a balance-of-terror concept—that "stability might be increased by additional armaments, including certain types of nuclear weapons."

CYRUS P. BARNUM, JR.

Department of Physiological Chemistry, University of Minnesota, Minneapolis

Meetings

Polar Wandering and Continental Drift

The ultimate goal of earth scientists is to integrate and collate evidence of apparently separate phenomena known about the physico-organic history of the earth into a rational, coherent, and demonstrable explanation of these facts. Attainment of this goal probably lies far in the future—or may be unattainable, because of a constant evolving conceptual relationship with unknown finite limits. Nevertheless, by necessity, periodic attempts are made to summarize existing knowledge and to visualize the complex as a whole, for it is by a process of establishing multiple working hypotheses that the validity of ideas can be tested. Unfortunately, too often a disciplined, rigorous, and impartial weighing of the evidence for and against a particular idea, or theory, is delayed because of preconceived ideas, inability to separate fact from theory, lack of information, or plain prejudice. But, on the other hand, great caution must be exercised before one of the "multiple hypotheses" is unequivocally accepted as a true conclusion: facts must be sought, and their interrelationships shown. Obviously, then, the first step in testing a hypothesis is presentation of the data in context; the second step is interpretation; while the third is attempted refutation of the interpretation or examination of the consequences of its acceptance.

Earth scientists have been and are confronted with a nearly infinite quantity of detail which is subject to arrangement in a great many ways. Often, the patterns used to categorize information are modes of convenience or experiency and, as such, are "working" hypotheses proposed for a practical purpose. Sometimes their immediate practicality is not obvious and their applications are not readily apparent, but many principles have been established or rejected only through trial and error over long periods of time.

Numerous familiar examples of long-delayed or reluctant acceptance of theoretical ideas subsequently shown to be true are easily recalled in connection with evolution, organic origin of petroleum, hydrothermal alteration, continental glaciation, and many other fields. But on the other hand, bold, courageous partisanship is to be desired only when it serves to bring forth truth from both protagonist and antagonist. As the stimulus of argument becomes the foil of truth, so diligent investigation denies unwarranted acceptance or rejection of possibly superficial evidence.

The concepts of continental drift and polar wandering should, therefore, be placed in proper perspective and attempts should be made to prove or disprove them scientifically and dispassionately. The demagogic and insincere approach is always that of introducing personalities into an impartial discussion for the purpose of concealing some deficiency of investigation or knowledge. As Longwell states: "We know too little about the Earth and its history to indulge in such final judgments . . . while we admit great gaps in critical geologic knowledge . . ." ["Continental Drift Symposium," Univ. of Tasmania (1958), pp. 1–12.]

The April symposium of the Society of Economic Paleontologists and Mineralogists in Atlantic City, N.J., on the "Mineralogic and Paleontologic Aspects of Continental Drift and Polar Wandering" was conceived to present a review of investigations in this field in recent years. Numerous workers have invested large quantities of effort and time in the physical and biological sides of this idea and have succeeded in raising a once disreputable hypothesis to a creditable position in which it becomes deserving of a complete re-examination and re-evaluation. Final proof, of course, has not been established, but, just as obviously, the recent studies have made it unwise to dismiss the concepts without added careful scientific investigations. The symposium was thus designed to stimulate work in this field by pointing out some of the problems to be solved. (See list of contributors to the symposium at end of this report.)

Hypothesis of continental drift. The idea of continental drift was originally proposed by A. L. Wegener [*Origin of Continents and Oceans* (Braunschweig, 1922)] in connection with his analysis of the origin of continents and oceans as a method to help explain anomalous distributive patterns of ancient climate zones [Koppen-Wegener, *Die Klimate der geologischen Vorzeit* (Borntraeger, Berlin, 1924)]. The implications of this proposal seriously challenged many of the beliefs and theories of the constitution of the earth, its physical properties, tectonics, and biologic developments. As a result a considerable furor of opposition arose on all counts, but, in particular, the geophysicists alleged that drift was out of the question because the crust could not endure such forces. Others denied the need for moving the continents to explain either mountain chains or animal and plant disposition in space and time relationships.

Many of the main objectives were directed toward the mechanisms of drift suggested by Wegener and subsequently to the geodetic studies of longitude determinations designed to demonstrate the westward drift of Greenland. These criticisms were and are quite valid insofar as the physical principles are concerned, but the basic and real question is not so much *how* but *has* shifting occurred? What evidence exists in support of this contention?

Evidence for continental movement. The demonstration of the possible actuality of continental shifting may be resolved by following several routes and attempting to integrate them individually into a mutually accordant whole. The usual avenues have been: geodesy, paleontology and stratigraphy, paleoclimatology, and geophysics. However, in latter years the quality of investigations in these areas has greatly increased because of added data, techniques, and new types of research.

Geodesy. The mensuration of the earth's surface—with determination of exact locations of geographic points—has long been used to "fit" the continental masses together. The commonly quoted concordance of South America with Africa has led to efforts to "fit" all land masses into an original or protocontinent called "Pangea." Much work by Carey on spherical projections and globes with various bathymetric levels led him to his orocline hypothesis and acceptance of the idea of an expanding earth.

Paleontology and stratigraphy. The fossil occurrence of warm-water faunas in present-day cold latitudes, of similar flora on separated continents, of glacial deposits in equatorial zones, and of many other apparently anomalous biologic situations has led to numerous investigations. K. E. Caster has contributed much on the Devonian and upper Paleozoic faunas of the Southern Hemisphere to show a good probability of contiguity of continents in the past. Ting-Ying H. Ma has studied Paleozoic coral distributions over the world and has concluded that continental shifting occurred on a grand scale. Through coral "belt" correlations in the various geologic periods, he has indicated their confinement to particular latitudinal zones, and, consequently, is able to locate inferred pole positions at successive times. However, he further notes that there are discrepancies in such pole positions which may only be resolved by assuming relative shift between continents as well as entire crustal shift.

S. Nordeng, working with stromatolites of the Huronian age in Michigan, shows they may have a preferred direction of growth and orientation seemingly directly dependent upon the angle of incidence of sunlight. Thus he feels it possible to locate the pole position at the time of growth in terms of present day latitude and longitude. During Lower Huronian time, by this method, he states one pole was at 4 degrees north latitude and 40 degrees west longitude. Later, in the Middle Huronian, a polar position was 5 degrees south latitude and 48 degrees west longitude.

As far as can be determined now, these data do *not* confirm the paleomagnetic observations of either Irving or Runcorn, both of whom have contributed extensively to the cause of paleomagnetic measurement and to its concomitant result of polar wandering through the ages [Irving, "Rock Magnetism: A new approach to the problems of polar wandering and continental drift," symposium, Univ. of Tasmania (1958), pp. 24–57; Runcorn, *Advances in Phys.* **4**, 244 (1955)]. Probably no other single line of investigation has done so much as this geophysical procedure to advance the cause of continental shifting and polar wandering. Certainly such confirmation studies by many eminent and thoroughly competent workers such as Runcorn, Irving, E. R. Deutsch, B. W. Wilson and R. H. Nanz, Jr., J. Hospers, A. Cox and R. R. Doell, and many others have elevated the hypothesis to a respectable level from its limbo of derision.

Strong support for the hypothesis of continental shifting and polar wandering has also been derived from many other sources. One of the more spectacular contributions are the paleoclimatic studies of G. W. Bain based on the "inalienable characteristics of the different latitudinal zones" which control life types, air circulation, ocean currents, and energy distributions in a major sense. When these characteristics are applied to ancient environments, interpretations show "shifts in the zones of high and low sun of about 90 degrees. . . ."

Finally, the oceanographic investigations by M. Ewing and B. Heezen of Lamont Geological Observatory have shed great light upon the geophysics of the ocean floor and the crust, as well as upon the ubiquitous oceanic ridges which more or less bisect the major oceans. These data have supplied precise and provocative knowledge of a once largely unknown quantity and seem to have added support to the contention of an expanding earth. As a result, a positive mechanism has been suggested by S. Warren Carey by means of which not only continental shifting may be accomplished, but also many of the observable tectonic features of the earth's surface may be rationalized.

It must be reiterated in conclusion, however, that these propositions and *hypotheses are not yet proved*, persuasive and inviting as they may be. Much rigorous and critical work remains to be done in many areas, but major avenues of investigation have now been suggested and the way for future work has been clearly indicated. I sincerely hope that an ever-increasing number of workers will be stimulated and encouraged to undertake some facets of these studies. The challenge is cast and the goals are nearly infinite in scope and size. The quantity of data is enormous, but it is hoped that the forthcoming volume of the Society of Economic Paleontologists and Mineralogists giving the papers of the 1960 symposium will be an anchor point for future investigations.

The 1960 SEPM symposium brought together leading authorities in these fields of study: S. Warren Carey, University of Tasmania, geodesy and tectonics; S. K. Runcorn, University of Durham (England), geophysics; B. W. Wilson and R. H. Nanz, Jr., Shell Development Co., geophysics; E. R. Deutsch, Imperial Oil Co., geophysics; B. C. Heezen, Lamont Geological Observatory, oceanography; G. W. Bain, Amherst College, paleoclimatology; Ting-Ying H. Ma, Taiwan University, paleontology; K. E. Caster, University of Cincinnati, paleontology; S. C. Nordeng, Michigan Tech., paleontology; W. L. Donn, Lamont Geological Observatory, glaciology; W. C. Gussow, Union Oil Co., tectonics; D. Swartz and D. D. Arden, Sohio Petroleum Co., tectonics.

ARTHUR C. MUNYAN
Sohio Petroleum Company, Oklahoma City, Oklahoma

Forthcoming Events

November

17–20. American Anthropological Assoc., Minneapolis, Minn. (B. J. Meggers, 1530 P St., NW, Washington 5)

17–20. Southern Thoracic Surgical Assoc., Nassau, Bahamas. (H. H. Seiler, 517 Bayshore Blvd., Tampa 6, Fla.)

18–19. American Medical Writers' Assoc., Chicago, Ill. (H. Swanberg, 510 Maine St., Quincy, Ill.)

21–23. Fluid Dynamics, annual, Baltimore, Md. (R. J. Emrich, Div. of Fluid Dynamics, APS, Dept. of Physics, Lehigh Univ., Bethlehem, Pa.)

24–25. American Physical Soc., Chicago, Ill. (K. K. Darrow, APS, 538 W. 120 St., New York 27)

24–26. Central Assoc. of Science and Mathematics Teachers, 60th annual conv., Detroit, Mich. (L. A. Conrey, School of Education, Univ. of Michigan, Ann Arbor)

25–26. American Soc. of Animal Production, Chicago, Ill. (C. E. Terrill, Animal Husbandry Research Div., Agricultural Research Center, Beltsville, Md.)

25–26. National Council for Geographic Education, Cincinnati, Ohio. (L. Kenndmer, Univ. of Texas, Austin)

25–16. Bahamas Medical Conf., Nassau. (B. L. Frank, P.O. Box 4037, Fort Lauderdale, Fla.)

27–1. Latin American Cong. of Neurology, Santiago, Chile. (R. Nunez, Almirante Montt 485, Dep. 11, Santiago)

27–2. American Soc. of Mechanical Engineers, annual, New York, N.Y. (A. B. Conlin, Jr., ASME, 29 W. 39 St., New York 18)

27–5. International Federation of Agricultural Producers, 11th conf., New Delhi, India. (IFAP, 1624 Eye St., NW, Washington 6)

28–1. Entomological Soc. of America, Atlantic City, N.J. (R. H. Nelson, 4603 Calvert Rd., College Park, Md.)

29–2. American Medical Assoc., Washington, D.C. (F. Blasinggame, 1535 N. Dearborn St., Chicago 10, Ill.)

30–2. Steels in Reactor Pressure Circuits, symp., London, England. (Secretary, Iron and Steel Inst., 4 Grosvenor Gardens, London, S.W.1)

December

1–16. Commission for Climatology, 3rd session, London, England. (World Meteorological Organization, Campagne Rigot, 1, avenue de la Paix, Geneva, Switzerland)

2–5. Central American Medical Conf., 8th, Panama City. (A. Bissot, Departamento de Saud Publica, Ministerio de Trabajo, Prevision Social y Salud Publica, Panama)

3–6. Visual Communications, 4th annual intern. cong., Chicago, Ill. (Visual Communications Cong., 10600 Puritan Ave., Detroit 38, Mich.)

3–8. American Acad. of Dermatology and Syphilology, Chicago, Ill. (R. R. Kierland, First National Bank Building, Rochester, Minn.)

4–6. Spectroscopy, annual southern seminar, Gainesville, Va. (Annual Seminar on Spectroscopy, Univ. of Florida, Gainesville)

4–7. American Inst. of Chemical Engineers, annual, Washington, D.C. (F. J. Van Antwerpen, AICE, 25 W. 45 St., New York 36)

4–9. Radiological Soc. of North America, Cincinnati, Ohio. (D. S. Childs, 713 E. Genesee St., Syracuse 2, N.Y.)

5–7. American Soc. of Agricultural Engineers, winter, Memphis, Tenn. (J. L. Butt, 420 Main St., St. Joseph, Mich.)

5–7. Electronic Industries Assoc., 3rd conf. on maintainability of electronic equipment, San Antonio, Tex. (E. B. Harwood, Office of the Secretary of Defense, Room 3D1018, Pentagon, Washington 25)

5–8. American Rocket Soc., 15th annual, Washington, D.C. (R. L. Hohl, ARS, 500 Fifth Ave., New York 36)

7–13. American Acad. of Optometry, San Francisco, Calif. (C. C. Koch, 1506–08 Foshay Tower, Minneapolis 2, Minn.)

9–10. The Myocardium—Its Biochemistry and Biophysics, New York, N.Y. (A. P. Fishman, New York Heart Assoc., 10 Columbus Circle, New York 19)

9–11. American Psychoanalytic Assoc., New York, N.Y. (D. Beres, 151 Central Park West, New York 23)

10–11. Academy of Psychoanalysis, New York, N.Y. (J. H. Merin, 125 E. 65 St., New York 21)

11–14. Hot Laboratory and Equipment Conf., 8th, San Francisco, Calif. (J. R. Lilienthal, Los Alamos Scientific Laboratory, P.O. Box 1663, Los Alamos, N.M.)

12–14. American Nuclear Soc. (Isotopes and Radiation Div.), San Francisco, Calif. (O. J. Du Temple, ANS, 86 E. Randolph St., Chicago 1, Ill.)

12–14. Water Pollution, natl. conf., Washington, D.C. (Natl. Conf. on Water Pollution, F. A. Butrico, Office of Engineering Resources, Div. of Engineering Services, U.S. Public Health Service, Washington 25)

12–16. Atomic Industrial Forum, conf., San Francisco, Calif. (D. J. Scherer, 3 E. 54 St., New York 22)

13–15. Eastern Joint Computer Conf., New York, N.Y. (E. C. Kubie, EJCC, Computer Usage Co., Inc., 18 E. 41 St., New York 17)

19–20. Statistical Mechanics, conf., London, England. (Organizing Secretary, Physical Soc., 1, Lowther Gardens, London)

22–2. Panamerican Diabetic Congress, 1st, British Honduras. (B. R. Hearst, Director, Diabetic Inst. of America, 55 E. Washington St., Suite 1646, Chicago, Ill.)

26–30. Inter-American Cong. of Psychology, 7th, Havana, Cuba. (G. M. Gilbert, Psychology Dept., Long Island Univ., Brooklyn 1, N.Y.)

26–31. American Assoc. for the Advancement of Science, annual, New York, N.Y. (R. L. Taylor, AAAS, 1515 Massachusetts Ave., NW, Washington 5.

27–14. Bahamas Surgical Conf., Nassau. (B. L. Frank, P.O. Box 4037, Fort Lauderdale, Fla.)

28. Association for Education in International Business, St. Louis, Mo. (J. N. Behrman, Univ. of Delaware, Newark, Delaware)

28–30. American Economic Assoc., St. Louis, Mo. (J. W. Bell, Northwestern Univ., Evanston, Ill.)

28–30. Econometric Soc., St. Louis, Mo. (R. Ruggles, Dept. of Economics, Yale Univ., New Haven, Conn.)

(See issue of 21 October for comprehensive list)

New Products

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Neither Science *nor the writer assumes responsibility for the accuracy of the information. All inquiries concerning items listed should be addressed to the manufacturer. Include the department number in your inquiry.*

■ MAGNETIC-TAPE SEARCH AND CONTROL SYSTEM employs time-code detection, using 24-bit, binary-coded-decimal time code. Search and playback are performed at any speed from 1⅞ to 150 in./sec and in either direction. Contact closures are provided for operation of auxiliary equipment during the interval between preset start and stop times. Early contact closures are provided to allow equipment to be brought up to speed. The time code being searched is continuously displayed in digital form. (Electronic Engineering Co. f California, Dept. Sci870, 1601 E. Chestnut Ave., Santa Ana, Calif.)

■ CENTRIFUGE for medical and industrial laboratories permits a wide selection of horizontal, angle, and basket heads. Speeds to 5500 grav are attainable. Where high centrifugal fields in small volume are required, a high-speed attachment will provide up to 37,000 grav. (International Equipment Co., Dept. Sci886, 1284 Soldiers Field Rd., Boston 35, Mass.)

■ PROGRAMMED-TEMPERATURE CHROMATOGRAPH permits column operation from ambient temperature to 500°C. Two columns are used, one for analysis and the other for column vapor-pressure compensation. Cams used for programming can be cut for any type of program desired. Carrier gas flow is controlled by differential controllers to avoid effects of change in column resistance with temperature. An air blower effects rapid cooling at the end of run. (Loe Engineering Co., Dept. Sci890, 232 N. Fair Oaks, Pasadena, Calif.)

■ LIQUID DETECTION SYSTEM uses a point sensor that is actuated by the damping effect of a liquid on a vibrating quartz crystal. All circuit elements are housed in a separate unit that may be removed up to 250 ft from the sensor. Liquid-level measurements are said to be repeatable to 1/32 in. Response time of the system is less than 40 msec, and operating temperature range is −320° to +160°F. Components designed for a particular medium are interchangeable. (Trans-Sonics, Inc., Dept. Sci892, Burlington, Mass.)

■ LIQUID DISPENSER delivers volumes said to be accurate to ±1 percent and reproducible to ±0.4 percent. Delivery is actuated by depressing a plunger. Spring-driven return of the plunger refills the syringe. Volume can be set from 1 to 100 percent of syringe capacity. Capacities available are 1, 3, and 10 ml. All glass valves are used. (Microchemical Specialties Co., Dept. Sci891, 1825 Eastshore Highway, Berkeley 10, Calif.)

■ SPECTRUM ANALYZER allows for the conversion of signals in the 450 kcy to 100 Mcy/sec range with use of an external oscillator, and automatically scans the difference frequency. Specifications include: variable sweep width, 0 to 100 kcy/sec with 150, 550, 2000, and 10,000 kcy/sec fixed sweep; 50 ohm input impedance; 60 db dynamic range; 20 μv sensitivity; 0.1 to 30 cy/sec scan rates. (Probescope Co., Dept. Sci894, 8 Sagamore Hill Dr., Port Washington, N.Y.)

■ MEMBRANE FILTER of a flexible cellulose material is available in pore sizes ranging from 0.2 to 10 μ. The pores, comprising more than 80 percent of the filter volume, are said to be uniform in size. Direct microscopic examination may be made of the filter. (Scientific Products, Dept. Sci887, 1210 Leon Place, Evanston, Ill.)

JOSHUA STERN

National Bureau of Standards, Washington, D.C.

PERSONNEL PLACEMENT

CLASSIFIED: Positions Wanted, 25¢ per word, minimum charge $4. Use of Box Number counts as 10 additional words. Payment in advance is required.

COPY for ads must reach SCIENCE 2 weeks before date of issue (Friday of every week).

DISPLAY: Positions Open. Rates listed below—no charge for Box Number. Rates net. No agency commission. No cash discount. Minimum ad: 1 inch. Ads over 1 inch will be billed to the nearest quarter inch. Frequency rate will apply to only repeat of same ad. No copy changes. Weekly invoices will be sent on a charge basis—provided that satisfactory credit is established.

Single insertion	**$40.00 per inch**
4 times in 1 year	**38.00 per inch**

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Replies to blind ads should be addressed as follows:
Box (give number)
Science
1515 Massachusetts Ave., NW
Washington 5, D.C.

POSITIONS WANTED

Research Assistant, bachelor's degree, 11 years' experience in chemical, animal, physiological procedures. Training varied and flexible enough to learn any assay or instrument analysis. Area location open. Box 200, SCIENCE. X

(a) **Ph.D.-M.D.** with radioisotope training; 5 years of anatomy teaching and research at medical school; available for teaching, research or administrative appointment. (b) **Ph.D.-D.V.M.** with 4 years of college teaching experience and pathology research including pharmacology and toxicology of feed additives; prefers research position. S10-4 Medical Bureau, Inc., Science Division, Burneice Larson, Chairman, 900 North Michigan Avenue, Chicago. X

POSITIONS OPEN

The Canadian Department of Agriculture, Ottawa, requires an

ENTOMOLOGIST

To plan and develop specialized research on the ecology of aquatic insects.

$8120–$9800

Qualifications include a Doctor's degree or equivalent in Entomology with specialization in ecology and several years' experience in experimental ecology.

Applications should be filed not later than 10 November 1960.

For details, write to
CIVIL SERVICE COMMISSION, OTTAWA
Please quote Competition Number 60-893.

PHARMACOLOGISTS

Ph.D.'s

Expanding pharmaceutical company near New York City offers opportunities to recent Ph.D.'s with training in biochemical pharmacology.

. . . Permanent positions
. . . Excellent benefit programs
. . . Pleasant suburban area

Submit complete résumé including salary desired

Box 199, SCIENCE

POSITIONS OPEN

Medicinal Chemistry

DIRECTOR OF MEDICINAL CHEMISTRY RESEARCH

. . . will direct activities of MEDICINAL CHEMISTRY RESEARCH as key member of our research team. Ph.D. in organic chemistry with ten to fifteen years postdoctoral experience in medicinal chemistry, half of this time in the pharmaceutical industry. Appointee must be self-motivated with proven idea ability and supervisory experience. If you qualify, send personal data to R. G. Jamison, Personnel Manager. Your reply will be held in strictest confidence.

The National Drug Co.
4663 STENTON AVENUE
Philadelphia 44, Pa.

PSYCHIATRIC INSTITUTE AND HOSPITAL—Offers challenging and unusually rewarding opportunities to qualified research scientists. Laboratories in various phases of activation include experimental psychology, neuroanatomy and neurohistochemistry, neurophysiology and socio-environmental studies. Positions available involve varying degrees of responsibility in the planning, development, coordination, and direction of research laboratories and programs. Inquiries are invited from individuals with an M.D. or Ph.D. degree and research competence in the following fields: **Human Genetics, Neuropathology, Virology.** Write Dr. Edward N. Hinko, Director, Cleveland Psychiatric Institute and Hospital, 1708 Aiken Avenue, Cleveland 9, Ohio. 10/28; 11/4

POSITIONS OPEN

CHEMISTS (4)

A Northern New Jersey food processing company has immediate openings in its expanding Technical Research Dept. for:

CHEMISTS (3)

B.S. or M.S. Research in various areas of organic and biochemistry. High academic standing; good background in organic chemistry; experience in proteins, carbohydrates and fats is helpful. 0 to 5 years' experience.

PHYSICAL CHEMIST, Ph.D.

Major duties include research on foods. Knowledge of physics; experience in electronics helpful. Interest in the food field essential; 0 to 5 years' experience.

Salaries commensurate with qualifications and experience. Liberal fringe benefits, 35 hour week. Send complete resume stating age, qualifications and experience.

Box 198, SCIENCE

(a) **Head of Research-Development Laboratories** of expanding drug firm; high salary; East. (b) **Biologist** experienced in environmental radio-active contamination, able to organize and direct studies, conduct pre- and postgraduate training, and make field trips; leading medical school, Pacific Coast; around $10,000. (c) **Physiologist** for human factors research on effects of whole-body vibration and response; able to originate and develop projects; medical school affiliation if desired; Midwest. (d) **Bacteriology-Public Health Professor** to develop virology program and teach; ample time for personal research; large university; around $9000; East. (e) **Associate Medical Director,** M.D. or Ph.D. degree for expanding drug manufacturer; Pacific Coast. (f) **Head of Virology Department** qualified in tissue culture for expanding research section of drug-biological firm; around $10,000; Midwest. (g) **Clinical Biochemist** to head section in hospital expanding to 600 beds; around $10,000; East. (h) **Physiologist or Neurophysiologist** to conduct advanced research at leading university; $9000–$11,000; South. (i) **Biochemist** for cancer and other medical research studies at large university research institute; East. (j) **Soil Scientist** trained in plant ecology or nutrition for research and teaching in university radiation division; $7000–$10,000; West. (Please write for details; also many other positions available through our nationwide service.) S10-4 Medical Bureau, Inc., Science Division, Burneice Larson, Chairman, 900 North Michigan Avenue, Chicago. X

Pharmaceutical Chemist. Two men with Ph.D. degrees or equivalent training (with or without industrial experience) required in the Pharmaceutical Product Development Department of a large ethical pharmaceutical company in upstate New York. Both positions involve research on pharmaceutical dosage forms. One man should also have a fairly strong background in organic chemistry. Work requires creativity and imagination. Excellent starting salaries and fringe benefits. Expansion of the company presents opportunities for advancement. Box 187, SCIENCE. 10/14, 21, 28

RESEARCH MICROBIOLOGIST

Ph.D. (under 35) or equivalent experience. Interest in **IMMUNOLOGY, VIROLOGY,** or **TISSUE CULTURE** desirable but not necessary.

Opportunity with an excellent future in an expanding program in vaccines and chemotherapy with an ethical manufacturer of pharmaceuticals and biologicals.

POSITION OFFERS:

- Profit sharing
- Liberal fringe benefits
- Modern laboratories and equipment.

Send résumé and salary requirements in confidence to:

DIAMOND LABORATORIES, RESEARCH DIVISION
2538 S. E. 43rd Street
Des Moines, Iowa

POSITIONS OPEN

Pharmacology

SENIOR PHARMACOLOGIST

. . . because of continued growth, our company is seeking an alert scientist to direct a PHARMACOLOGY RESEARCH UNIT. Ph.D. degree in pharmacology plus three to five years in post-doctoral experience, mostly in the pharmaceutical industry. Must be capable of directing work of others. Send résumé and salary requirements to:

R. G. JAMISON
PERSONNEL MANAGER

The National Drug Co.
4663 STENTON AVENUE
Philadelphia 44, Pa.

PHARMACOLOGIST or PHYSIOLOGIST, Ph.D. with several years' experience in the investigation of autonomic drugs. Must have demonstrated ability to do independent research.

BIOCHEMIST, Ph.D. with proven research experience in protein chemistry and enzymology.

Excellent working conditions in a new pharmaceutical plant, fine benefit program with profit sharing. Live near your work in the San Fernando Valley. Write John Permantier, Personnel Manager.

Riker Laboratories, Inc.
Northridge, Calif.

Representative Wanted in your territory. From your desk you can earn a substantial addition to your income. Only written contacts with your clients! Write for particulars and further details to Karl Kuehne Publishing Co. (Verlag Karl Kühne). Vienna 66, P.O.B. 128, Austria.
8/26; 9/30; 10/28; 11/24; 12/30

TECHNICAL SALESMAN

For expanding west coast manufacturer of clinical and analytical instruments. Distribution through major dealer organizations. To Travel primarily east coast and midwest.
Salary + Stock option incentive

MECHROLAB, INC.
1062 Linda Vista Ave.
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VETERINARY PATHOLOGIST

Supervision of diversified research programs in toxicology and metabolism using large animals, including dogs, primates, economic animals, and so forth; except contribution to design of and coordination of experiments; histopathology evaluation is a primary responsibility.
Salary open to qualified scientist.
Write or call (collect):

Personnel Manager
Hazelton Laboratories, Inc.
P. O. Box 30
Falls Church, Virginia
JEfferson 2-5800

VIRUS RESEARCH

M.D. or Ph.D. interested in infectious diseases, basic studies on mechanisms of infection and on etiology, pathogenesis and epidemiology of virus diseases of infancy and childhood. Excellent facilities. Salary $6000 per annum. Address

Box 195, SCIENCE

The Market Place

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DISPLAY: Insertions must be at least 1 inch in depth. Weekly invoices will be sent on a charge account basis—provided that satisfactory credit is established.

Single insertion	$40.00 per inch
4 times in 1 year	38.00 per inch
7 times in 1 year	36.00 per inch
13 times in 1 year	34.00 per inch
26 times in 1 year	34.00 per inch
52 times in 1 year	32.00 per inch

For PROOFS on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

BOOKS AND MAGAZINES

Your sets and files of scientific journals

are needed by our library and institutional customers. Please send us lists and description of periodical files you are willing to sell at high market prices. Write Dept. A3S, CANNER'S, Inc. Boston 20, Massachusetts

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MAMMARY TUMORS IN MICE

AAAS Publication No. 22. By the staff of the National Cancer Institute, National Institutes of Health. F. R. Moulton, Ed.

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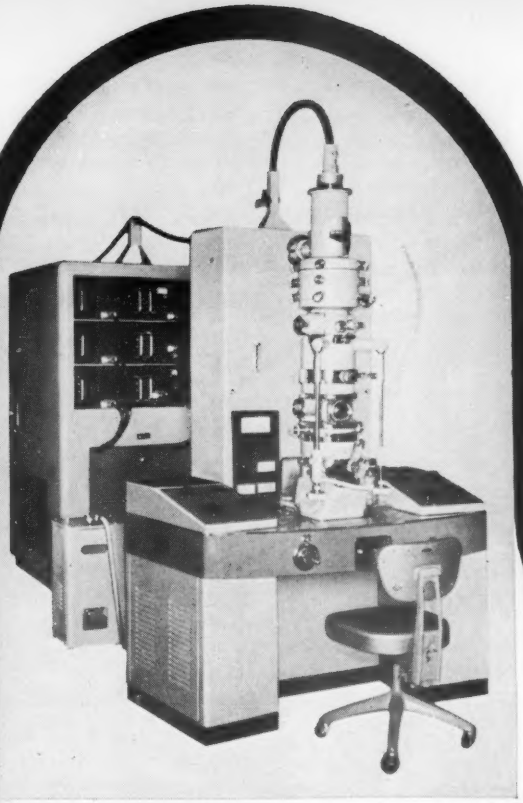
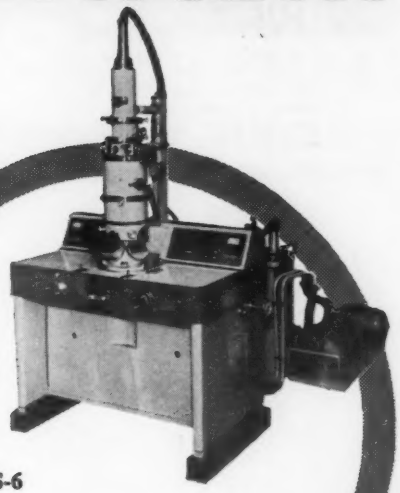


HU-11



HS-6

Permanent magnet-lens system
20 AU resolution.
Suitable for medical purposes
Easy operation

Complete **HITACHI** Electron Microscope For All Scientific Institutes And Laboratories

Direct Magnification : 250,000 Times
Resolving Power : 8 ~ 10 AU

- **Accelerating Voltage: 100,75 and 50KV**
- **Optical System: 3-stage magnetic lens system, 4 turret projection lenses, interchangeable during operation.**
- **Magnification: (Electronic) 400~250,000X**
- **Resolving Power: 8~10AU**
- **Minimum Area of Selected Field: 1 μ^2**
- **Accessories: Specimen heating and cooling devices, X-ray microscope unit, holder for diffraction, etc.**

"HITACHI, Ltd. has now developed the new model HU-II, a unit featuring extremely high resolving power and being able to attach many kinds of accessories".

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Cable Address : "HITACHY" TOKYO

NUCLEAR REVIEWS

from

NUCLEAR-CHICAGO

You are looking into the lattice of the Nuclear-Chicago Model 9000 Subcritical Student Training Reactor. Each tube projecting out of the water contains 5 natural uranium slugs 1" in diameter by 8" long. The center tube holds a neutron source to initiate and maintain a chain reaction.

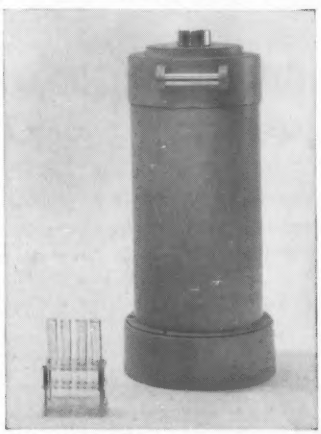
The Subcritical Assembly is designed so students themselves can change the lattice shape or the source position and study the effect of these changes on neutron distribution, multiplication, and scattering. The parts of the 9000 cannot be arranged in any way to make the device critical. The number of neutrons in the assembly never exceeds 6 to 7 times the neutron source strength. No special shielding is required, no operator licensing, no involved safety program.

The water moderator allows placement of foils, detectors, and absorbers at any point in the lattice. An automatic traversing mechanism, like the one shown over the tank, is available to move a detector through the lattice to permit continuous automatic recording of the flux distribution.

The 9000 is in use today in more than 20 colleges and universities. Its low initial cost, simple upkeep, and the fact that its fundamental characteristics are nearly identical with those in a full scale power or research reactor make it an ideal training device. We would be pleased to send you full details.

NEW SCINTILLATION WELL DETECTOR TAKES 20ml SAMPLES

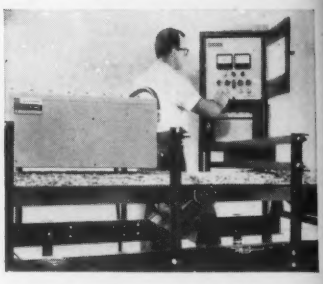
The $2\frac{1}{32}$" diameter well in conventional scintillation well detectors can be frustratingly small. Suppose you have a large volume sample (blood, for instance) that contains a very small amount of radioactivity. You naturally want to count the largest volume possible to increase the accuracy and speed up the measurement. But, that little well puts an end to efficient thoughts like that. The maximum volume you can insert into the well is about 5 ml.



Be frustrated no more! Nuclear-Chicago has designed a new scintillation well detector with a great big 3" diameter crystal with a great big $1\frac{1}{4}$" diameter well. Our new DS-303 accepts samples with volumes up to 20 ml. Now you can cut the amount of labelled material used in your experiment by a factor of four, analyze samples with lower specific activities, speed up counting of routine samples, etc., etc.

We have a new 4-page specification sheet describing the DS-303. Write today for your copy.

MOISTURE-DENSITY MEASUREMENTS ON THE PROCESS LINE



Here is a photograph of the first nuclear gauge ever developed to measure moisture content of bulk materials right on a conveyor belt. It is one of four new process control instruments developed in the past year at Nuclear-Chicago.

The four gauges are designed for measurement and control of *moisture* and *density* of materials on conveyor belts, in bins and hoppers, and in tanks, mixers, and blenders.

Each instrument series consists of three basic parts: a measuring head, an electronic read-out, and a recorder/controller which displays the desired information and controls the measured variable. Density measurements make use of gamma reflection and transmission; moisture measurements are accomplished by neutron reflection methods.

We have an 8-page brochure describing these four new gauges. Ask for the "Qualicon" brochure.

nuclear-chicago
CORPORATION
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